Curating Semi-Synthetic and Synthetic Fibres and Fabrics

DATS in partnership with Plastics SSN

DATS Dress and Textile Specialists

PSSN Plastics Subject Specialist Network

Art Fund_

This guide is the result of a collaboration between the Dress and Textiles Specialists (DATS), led by the Victoria and Albert Museum and Glasgow Museums, and the Plastics Subject Specialist Network (PSSN), led by the Museum of Design in Plastics (MoDIP). Its development has been made possible by an Art Fund Curatorial Networks Grant with additional funding from the British Plastics Federation, Worshipful Company of Horners, and the Plastics Historical Society.

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This is a peer reviewed resource. It can be amended and updated. Please contact us via the contact form on the website https://dressandtextilespecialists.org.uk/ with your comments and corrections.

The purpose of this guide is to enable participants to improve the documentation and interpretation of collections and make them accessible to the widest audience. It is intended to be used at DATS and Plastics SSN workshops and as a means of sharing the knowledge communicated in the workshops with colleagues and the wider public. It is also intended as a stand-alone guide for basic synthetic textile identification.

This text is also available as an online guide at www.modip.ac.uk/projects/plastics-ssn

Other workshops / information packs in the DATS series:

Identifying Textile Types and Weaves

Identifying Printed Textiles in Dress 1740–1890

Identifying Handmade and Machine Lace

Identifying Fibres and Fabrics

Identifying Handmade Lace

Identifying Woven Textiles 1750–1950

Front cover image: Salvatore Ferragamo shirt and skirt of woven Orange Fiber viscose and silk, V&A: T.1710:1, 2-2017.

Contents

1. About the guide

1.1 Introduction

This guide focuses on garments made of fibres known as semi-synthetic and synthetic. We have classified all fibres as either 'natural' (e.g., cotton and silk), 'synthetic' (e.g., nylon and acrylic) or semi-synthetic (e.g., viscose rayon and acetate rayon). All these fibres are polymers, that is to say they are formed by a process known as polymerisation in which small molecules called monomers combine chemically to produce large, chainlike molecules. Synthetic fibres are completely artificial – all the processes of manufacture are carried out in factories starting from basic raw materials such as natural gas or petroleum; semi-synthetic fibres, on the other hand, start from the polymers found in plant or animal materials (cellulose or proteins), which man then further modifies by physical and chemical treatments providing fibres suitable for textile use. In semi-synthetics, therefore, nature has done the polymerisation step, man has done the rest. For a more in-depth explanation please see section 2.1 Simple polymer chemistry.

The guide brings together knowledge provided by a variety of textiles and plastics experts including conservators, curators and scientists from the Dress and Textiles Specialists (DATS) and the Plastics Subject Specialist Network (PSSN). The methodology is described in section 8. Methodology and contributors. In addition, we have used a wide variety of sources which are referenced in section 8. Bibliography and other resources. This section lists useful published glossaries including the following recommendations: Condé Nast (n.d.), *The Sustainable Fashion Glossary*, Edwina Ehrman, (2018) *Fashioned from Nature* and Clive Hallett and Amanda Johnson, (2014) *Fabric for Fashion: The Complete Guide*.

1.2 How to use this guide

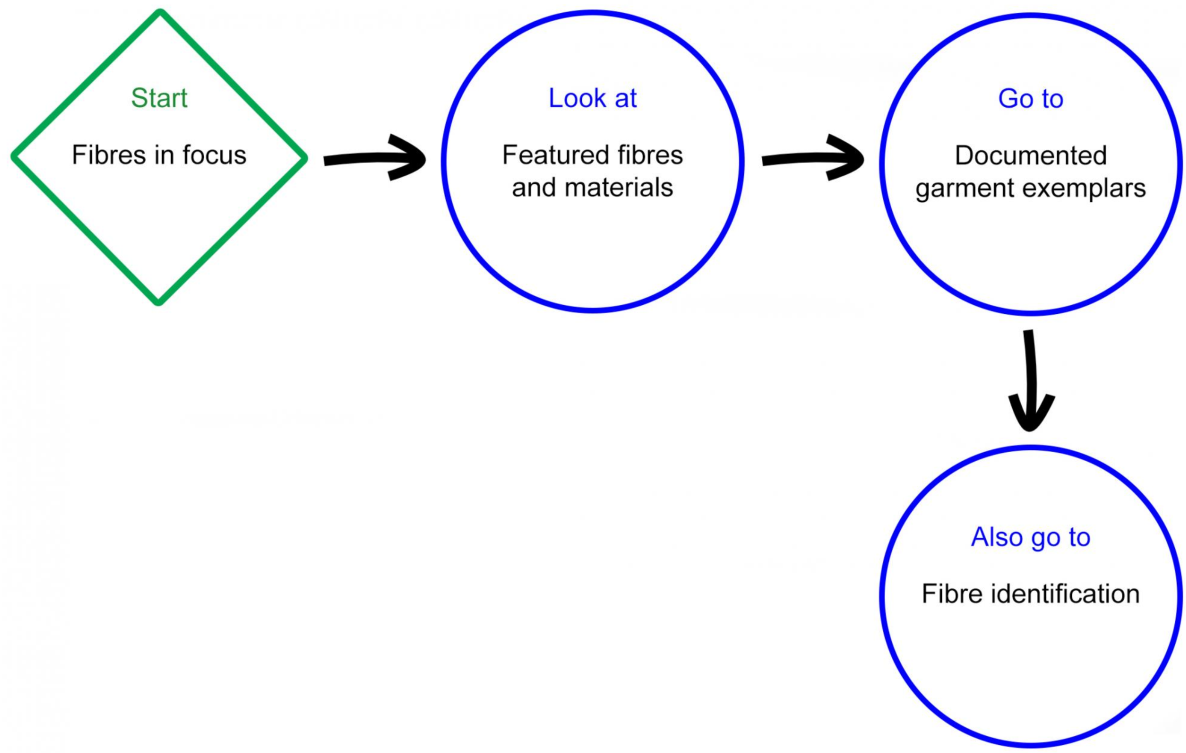
There are many ways of using this guide. It can be read like a book or manual from beginning to end but it is likely that often users will be especially interested in particular aspects or looking to answer specific questions. If this is the case, it will still help to familiarise yourself with its structure, but we have identified five paths through its sections, some more obvious than others, in keeping with the guide's aims expressed in section 1.

The guide can also be searched. Searches made on the website version (www.modip.ac.uk/projects/curators-guide-synthetic-garments) will search the whole Museum of Design in Plastics' website, thus will bring up entries not only within this resource but on the website as a whole. If you wish to restrict your search to this resource, please search the DATS downloadable booklet.

If you find passages or diagrams you think you may wish to refer to often, you are welcome to copy and paste them. For example, if you would like to have the information on Care and degradation provided in Featured fibres and materials more easily to hand just copy them to where is convenient for you, either within the downloadable version or make a document of your own. Equally, you may like to collect all the diagrams together into a single document. Please note, however, that requests to use the images of the documents should be made directly to the relevant collection.

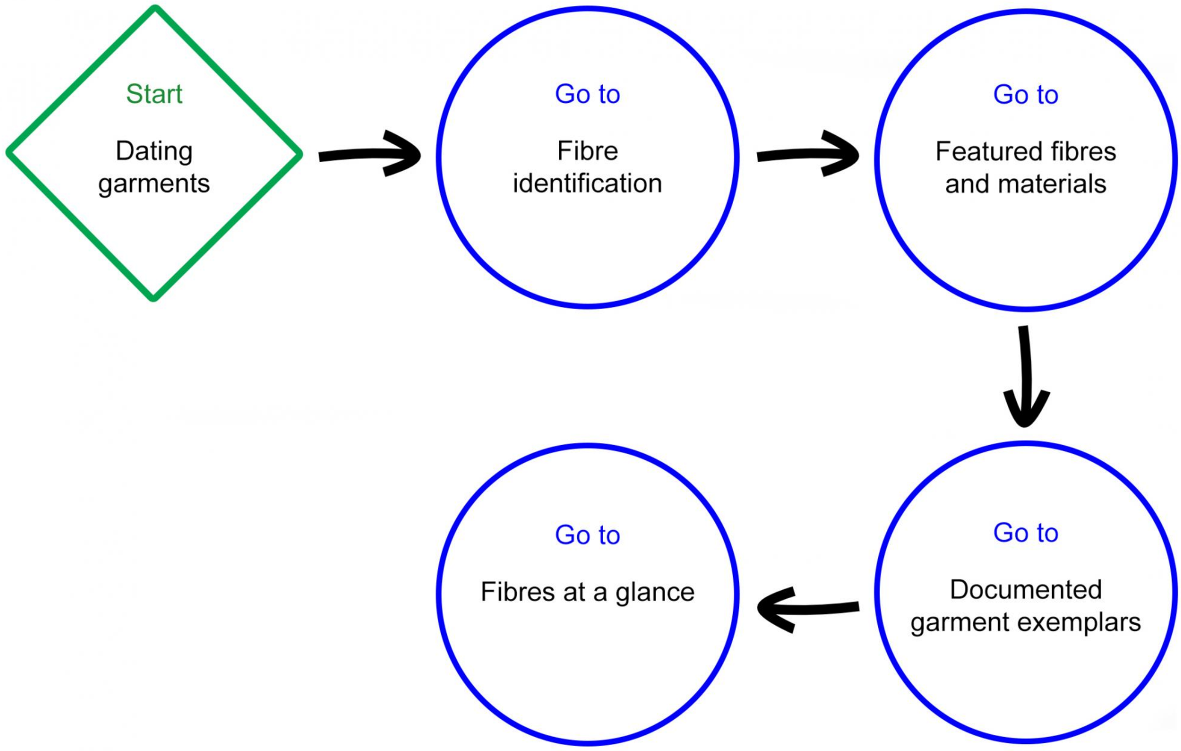
Some terms used may not be familiar to all users. Terms are explained in the Glossar. If you need information on a term not featured, please let us know via the contact form on the website https://dressandtextilespecialists.org.uk/, so that we can add an explanation for it.

Understanding semi and fully synthetic fibres



This path introduces the science underpinning their creation, how they are created, the character of different fibres and the issues they raise, and how and in what kind of garments they are used.
Start with section 2 Fibres in focus: whole section but in section 3 limit yourself to the fibres of particular interest to you.
→ section 5 Documented garment exemplars: look just at the entries for garments made from the fibres of particular interest to you. Fibre entries in section 3 are cross-referred to the documented garments containing them.
→ You may also like to look at information about these fibres in section 4.4 Fibres under the microscope.

Semi and fully synthetic fibre identification



This path provides guidance on the identification of the fibre(s) in a particular piece of fabric. Start with section 4.3 Dating garments: this section should help you place your garment within a date range. It includes a fibre timeline which enables you to see quickly when potential fibres became commercially available, thus whether their existence falls within the date range of your garment.

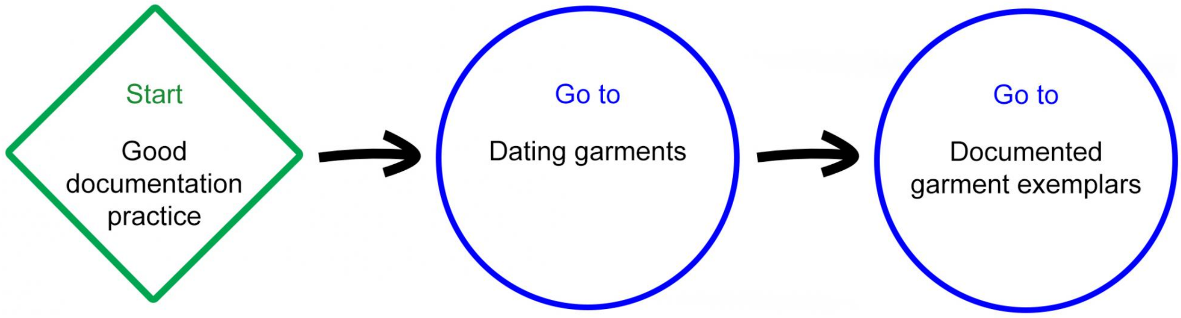
→ section 4.4 Fibre identification: general tips.

→ section 3 Featured fibres and materials: look at the fibre types you think could be the fibre in your garment to find out more about the different potential fibres' characteristics.

→ section 5 Documented garment exemplars: look just at the entries for garments including the fibres of particular interest to you. Fibre entries in section 3 are cross-referred to the documented garments containing them. You will be able to compare your garment with garments fibres that have been identified through scientific analysis.

→ section 2.4 Fibres at a glance: once you have identified, or potentially identified your fibre, these tables give the various, generic, common and trade names the fibre is known by. We have opted to call the fibre by the generic name given in bold in the first column of information about each fibre type.

Documenting semi and fully synthetic garments



This path provides guidance on ways to find required in formation and good practice.
Start with section 4.2 Good documentation practice: tips, pitfalls and good practice guidance on fibre identification, country of production, labels and measurements. It also leads you to other in-depth information in other parts of the guide.
→ section 4.3 Dating garments, for tips on dating garments.
→ section 5 Documented garment exemplars: an extensive range of documented garments as examples of good practice.

Care of semi and fully synthetic garments

This path provides guidance on the care of semi and fully synthetic garments in the museum environment.
Start with section 4.6 Caring for synthetic garments: guidance on environmental conditions, storage, handling and display, and examples of degradation.
→ section 3 Featured fibres and materials: look only at fibre types of concern to you.
→ section 5 Documented garment exemplars: look only at garments including fibre types of concern to you. Fibre entries in section 3 are cross-referred to the documented garments containing them.

Display narratives

This path provides ideas of ways to engage the public with the synthetic garments in your collection. Start with section 6 Potential narratives and research areas: consider the garments you wish to display in relation to the subject areas outlined.
→ fibres of interest to you in Featured fibres and materials.
→ You can also search the guide under headings of interest which will also bring up fibres in section 3 Featured fibres and materials: here you will find narrative ideas relating specifically to those fibres. Consider these ideas against the garments in your collection.

The guide is available in two formats: online at www.modip.ac.uk/projects/plastics-ssn and as a downloadable resource at dressandtextilespecialists.org.uk/guides. Please note the format differs slightly between the DATS booklet and PSSN guide, but the technical content is the same. It is a peer-reviewed resource which can be amended. Please let us know how it works for you and contact us via the contact form on the website https://dressandtextilespecialists.org.uk/ with your thoughts, comments and corrections.

1.3 Guide aims

Outside the scientific community, knowledge and understanding of synthetic textile fibres in museum collections tends to be diffuse and limited. As a result, garments made from these synthetic fibres are liable to be neglected. This guide addresses this knowledge gap. Its aims are:

- to bring together in one document, key information to support the curation of semi-synthetic and synthetic garments of all types.
- to increase confidence nationally in the curation of semi-synthetic and synthetic garments: their history, interpretation, care and identification.
- to improve the ability of museums to engage the public with these parts of their collections whatever the focus of the museum.

1.4 Intended users

We hope that the guide will be useful to curators and researchers at all levels of knowledge, but it has been written principally to increase understanding of these object types among curators and other collection care professionals without specialist expertise in textiles and fashion or scientific knowledge of semi-synthetic and synthetic materials. It also endeavours to address the needs of those without access to sophisticated technology and in-house conservators. Its contents are designed to be applicable not only to museums where garments are central to their subject but also to those with a different focus, for example sport, warfare, or firefighting, where garments may be a small part of the narrative but often those in which synthetic fibres are widely used.

1.5 Scope

Many of the issues that synthetic garments present are shared by garments made of traditional materials. In the interest of brevity, this guide focuses specifically on the issues that are peculiar to garments made of semi and fully synthetic materials.

Materials: we have taken a selective approach based on the materials used in the garments documented in section 4. The collections which supported this project offered these garments as exemplars. The collections have many materials in common and we have featured these alongside some seemingly more unusual materials and others which represent fibre innovations that may be commonly used in the future. The latter include Polylactide (PLA) which we decided to include as an example of a bio-based fibre even though none of the collections with whom we worked has an example of a garment made using this technology yet.

Garment types: these are limited to items that are worn but exclude shoes as DATS intend to create a separate resource on footwear. Accessories are limited to those found on garments such as belts, buckles and buttons. The clothes featured in the guide range from made-to-measure outfits to street style and protective wear alongside a core group of ordinary, everyday clothes. All were made for adult wearers.

Ways of making: most of the garments were manufactured commercially. Some were home-made.

Date span: we have tried to survey the fullest possible range of semi and fully synthetic materials from their invention in the nineteenth century up to the present. We regret that we have been unable to include documented exemplars of some of the very earliest semi-synthetic materials, for example Chardonnet silk and more examples of regenerated protein fibres.

Geographical coverage: up to the middle of the twentieth century, most of the featured garments and the fabrics from which they are made, originate in Western Europe and the USA. Thereafter, there is a wider range of countries of origin, reflecting the increasing globalisation of production. However, it is important to remember that manufacturing semi-synthetic fibres before the World War Two was not limited to the USA and Western Europe. By the 1930s Japan, for instance, was among the world’s leading producers of viscose rayon.

2. Fibres in focus

2.1 Simple polymer chemistry

For people with little or no knowledge of chemistry.
All matter (solids, liquids and gases) is ultimately composed of atoms. By 'ultimately' we mean that an atom cannot be broken down into further smaller bits of the same kind. There are more than 118 different kinds of atoms, each kind being known as an element. However, atoms are usually joined together with other atoms which can be of the same or of a different kind. Atoms combined with other atoms are called molecules, the linkages between the atoms being called bonds. Molecules containing different kinds of atoms are called compounds. The number and kind of each of the atoms in the molecule, their relative positions and the nature of the bonds joining them, make a unique compound. These factors constitute what is called the structure of a molecule.

Chemistry is conveniently divided into different areas. The area dealing with compounds of the element carbon is known as organic chemistry. In the field of textile organic chemistry, compounds comprising atoms of carbon with those of hydrogen, oxygen, nitrogen or chlorine or combinations of these, are the most common. Each element is represented by an atomic symbol; in the case of the above five elements the symbols are: C, H, O, N and Cl respectively. The molecular structure of an organic compound can be displayed using these symbols joined up by short lines or sometimes a double line (rarely, a triple line) representing the bonds. For example, a molecule of water would be shown as H–O–H. It is interesting that these elements have specific capabilities of joining up — that means the number of bonds they can make to other atoms. In the case of our five elements C, H, O, N and Cl these numbers are 4, 1, 2, 3 and 1 respectively. An atom's combining number is called its valency and it is inherent in the nature of the atom.

Although these valencies restrict atoms' combining power, organic compounds are unimaginably varied, as are their properties. For example, a particular compound might decompose spontaneously at room temperature, whereas another is stable but will decompose when heated. Decomposition means breaking up the original structure to form smaller and different molecules. However, specific desired changes in the molecular structure of an organic compound can be brought about by processes called chemical reactions. For example, a chemical reaction can be of the form Compound A mixed with Compound B reacts to form Compounds C and D. Sometimes minor amounts of other substances known as catalysts are added to start or to speed up reactions.

Some molecules are very large and contain groups of atoms which are repeated over and over again being held together by strong chemical bonds. These are known as polymers and the process by which they are made is called polymerisation.

Chemical substances are often categorised based on the nature of their principal structural features. Thus, we have alcohols, esters, amides, carboxylic acids, etc. These kinds of terms are useful in describing a compound with such a group in it. It is the reason there are so many fibres called polyesters and polyamides, the prefix ‘poly’ meaning that many of the indicated groups (ester or amide) are repeated in the molecule.

Many polymers are synthetic, e.g., polyamides, polyesters etc., made from petroleum for example, and many others occur naturally, e.g., proteins, carbohydrates etc. However, several important polymers are prepared by converting a naturally occurring polymer into a fibre suitable for making textiles. Such fibres are often called semi-synthetic. Thus, a major component of wood is cellulose; a naturally occurring carbohydrate polymer which can be treated to convert it into viscose — a semi-synthetic fibre that is still a carbohydrate polymer but now in fibrous form suitable for textile use. Cotton and flax are also forms of cellulose, but they are suitable for textiles without the kind of treatment needed to make viscose. All chemical reactions in nature take place at ambient temperature and pressure and are mediated by enzymes. Enzymes are proteins with specific structures which act as catalysts for the whole gamut of natural processes, one of them being polymerisation. By contrast, the polymerisation reactions used to manufacture semi-synthetic or fully synthetic fibres, need varied conditions, temperatures, pressures etc., according to the process, and often require catalysts which at the present time are never proteins.

The polymer called cellulose is composed of repeating groups having the structure of glucose, which is itself composed of six carbon atoms, twelve hydrogen atoms and six oxygen atoms. Glucose has a length of 1 nanometre (10^{-9}m). In the fibre there are several hundred of these glucose units, largely strung in a line. Each glucose unit has three places on it which can react with other substances. In practice the substance with which cellulose is most commonly reacted is acetic anhydride, and the product is a variety of cellulose acetate. As there are several hundred (x3) places where a cellulose molecule can react with acetic anhydride, a vast number of cellulose acetate varieties will be formed. The principal factors affecting this reaction are the quantity of acetic anhydride used in relation to the amount of cellulose, how long the reaction is allowed to take place and the temperature. Note that the reaction products are always going to be mixtures with different amounts of acetate except when conditions are such that all the glucose groups in all of the cellulose molecules are fully reacted. In that case the product will be cellulose triacetate. Both the fully and the partially reacted varieties are suitable for commercial use, the partially reacted ones being called cellulose diacetate. In practice, for convenience and for historical reasons, cellulose acetate is the name given to this partially reacted product.

Summarising, polymers are large molecules, comprising repeated groups of atoms all being held together by strong chemical bonds. All natural, semi and fully synthetic fibres are polymers.

2.2 Fibre creation

Extrusion: most synthetic and semi-synthetic fibres are created through the process of extrusion, where a viscous substance made from polymers, either in solution or molten is forced through a spinneret (a plate or nozzle with tiny holes) creating continuous filament fibres.

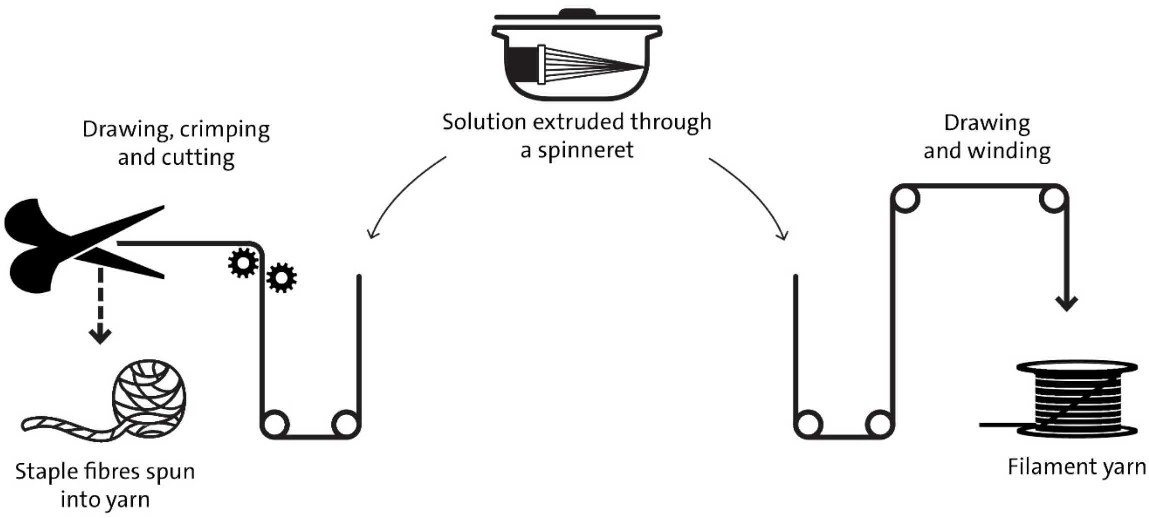
There are three main types of extrusion: melt, dry and wet spinning. Less common methods of extrusion include electrospinning (used for micro and nano fibres) and blow spinning (used for non-woven textiles).

Melt spinning extrusion: the polymer is heated until it becomes a liquid of a viscosity suitable for extrusion. It is then fed through a spinneret into a cooler air stream and the filaments solidify. Melt spinning is used for thermoplastics such as polyester and polyamide.

Dry spinning extrusion: the polymers are dissolved in a solvent. The resulting solution is then fed through a spinneret into a warm air chamber where the solvent evaporates, and the polymer filaments solidify. Dry spinning is used for acetate, triacetate, and some acrylic, spandex, vinal and PVC fibres.

Wet spinning extrusion: the polymers are dissolved in a solvent. The resulting solution is then fed through a spinneret into a coagulating bath where the solvent is removed, leaving the polymer filaments. Wet spinning is used for lyocell, viscose rayon, and some spandex PVC, vinal, and acrylic fibres.

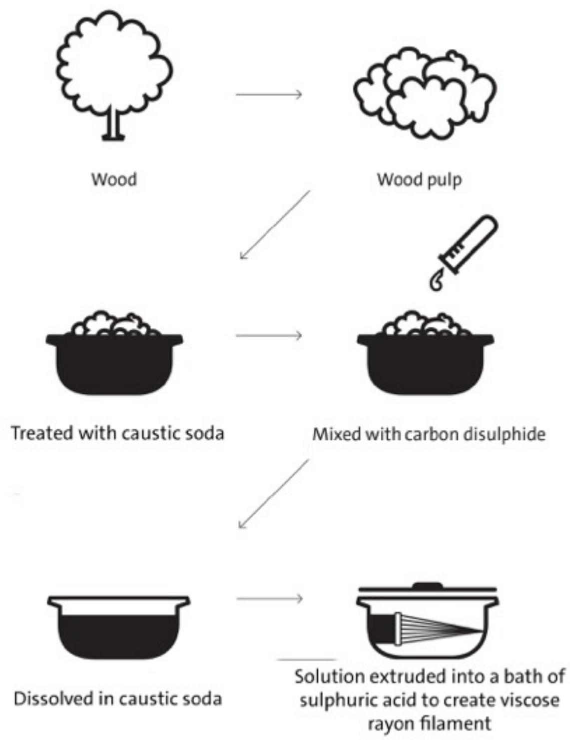
After extrusion: the fibres are drawn and either kept as filament or cut to shorter lengths (staples) and spun into a staple yarn.



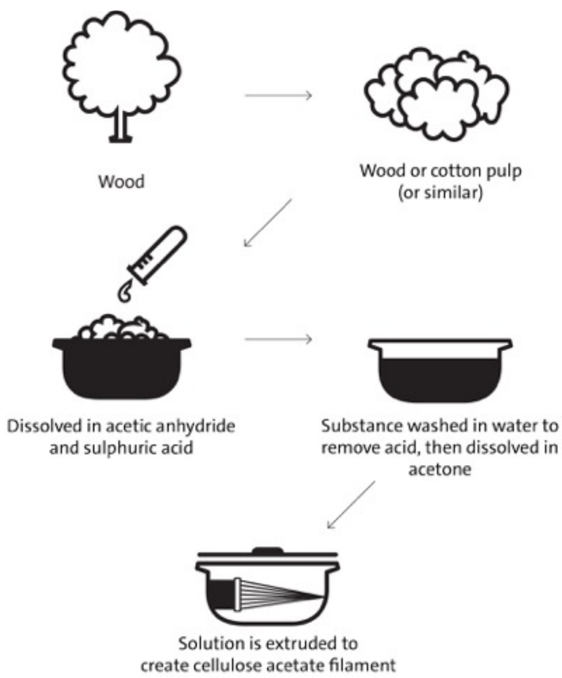
2.3 Fibre conversion processes

How the starting material is converted into the fibre product can be hard for those lacking a scientific background to understand. The following graphics provide a simplified visual explanation of the process from the starting material to the creation of usable fibres for seven of the most frequently encountered semi-synthetic and synthetic fibres. They are presented in the order in which the fibres were invented to provide a sense of how the processes developed and were refined.

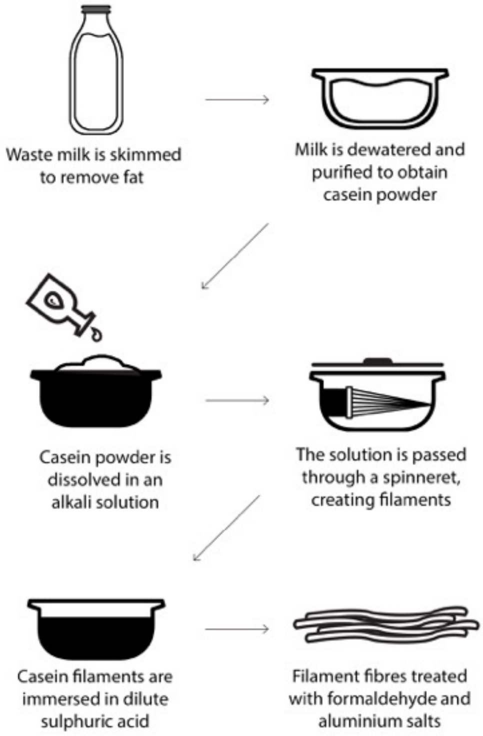
Viscose Rayon



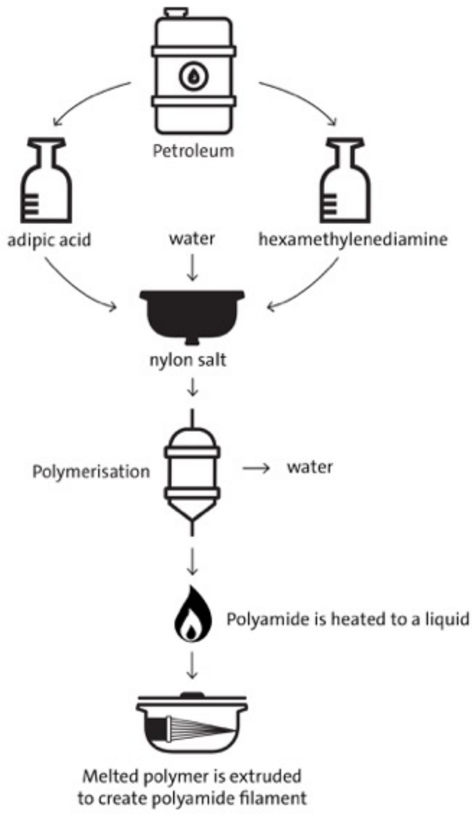
Acetate Rayon



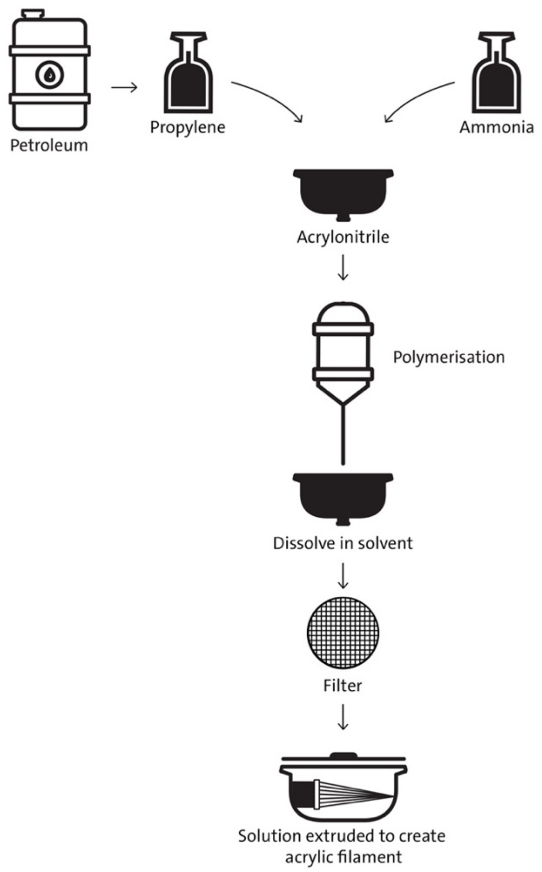
Casein fibre



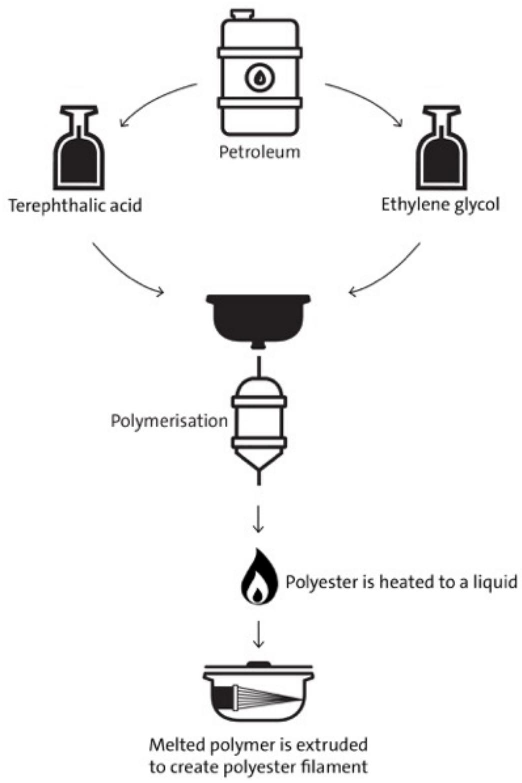
Nylon



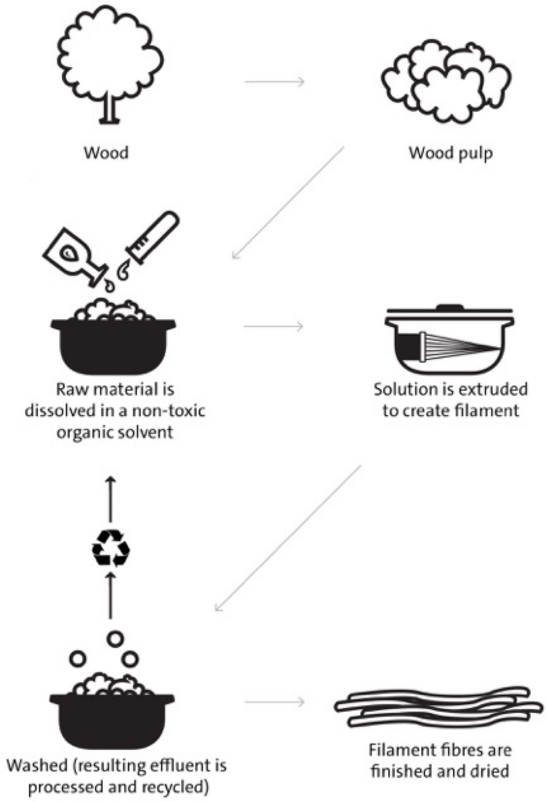
Acrylic



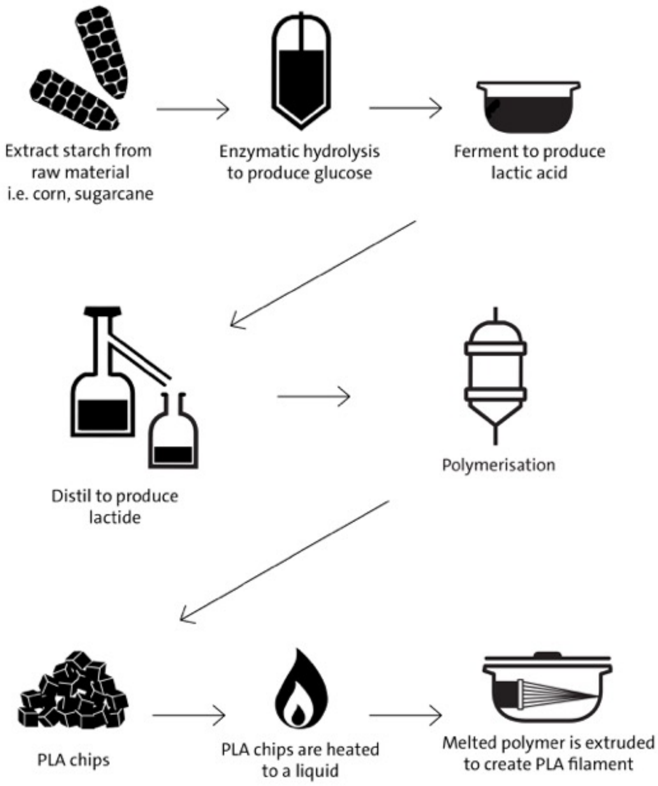
Polyester



Lyocell



Polylactide



2.4 Manufacturing hazards

Fibre: chemicals associated with the fibre manufacturing process, as well as being a direct risk to factory personnel, can also be an environmental hazard through leakages or poorly managed liquid and gaseous effluents. When production of the first semi-synthetic fibres started on a large scale, textile and other manufacturing industries took little account of such hazards, sometimes with life changing and fatal consequences. However, in the second half of the twentieth century as technology improved and concerns about human health and welfare and the environment became matters of wider public interest, the control of toxic substances improved greatly. Today, at a time when manufacturing is global, although strict manufacturing controls and tolerances are mandatory in some countries and have reduced risks to currently acceptable levels, there is a continuing need for progress in risk reduction, particularly in those countries where most textiles are now made.

From fibre to cloth: the process of transforming fibre into cloth involves many processes. Spinning converts the fibre into yarn which can be woven or knitted, made into a non-woven textile, or used to create a specialist fabric structure such as a pile fabric or lace. Dyeing the yarn can take place either before or after it is made into cloth. Dyeing and/or printing both involve a series of preparatory processes. After colouring, the cloth will undergo further physical and chemical finishing to prepare it for its end use (see section 2.7 Coatings). All these procedures can involve potentially harmful chemicals which pose a risk if they are not strictly controlled. There are also concerns about the potential health implications to wearers from chemical residues which survive in garments at the point of sale. This is the subject of important scientific research. Alternative, less toxic chemistries are also being developed to raise safety standards.

2.5 Fibres at a glance

Those fibres known as semi-synthetic are regenerated from two types of naturally occurring materials: cellulosic materials such as trees, cotton and woody plants and proteins such as milk, soybeans and groundnuts. Both types are also known as regenerated fibres.

Fully synthetic fibres are manufactured primarily from petroleum or natural gas although, in response to the relatively recent search for more sustainable starting materials, they may also now be plant based. They differ however from those that are known as semi-synthetic or regenerated fibres because man, rather than nature, does the polymerisation.

These tables include all classes of semi-synthetic and synthetic fibres which have been made in commercial quantities and are used as major components of textiles to date. They aim to capture in a simple and visually accessible way the complexity of their development, and the relationships between them. They include their commonly used names and starting materials, the characteristic part of the conversion process, the resulting fibre product, the most encountered trade names of the fibre or textile, and the date of first commercial manufacture, the company and the country. Frequently, different sources cite different facts in this respect. In particular, the beginning of commercial manufacture of a fibre is open to different interpretation thus these dates should be taken as a guide only. Table 4 shows non-fibre materials that appear in the Documented garment exemplars as rubber substitutes or waterproofing.

Table 1. Cellulose-derived fibres (semi-synthetic)

Generic and common names of the fibre. Principal name in **BOLD**	Commonly used starting materials[1]	Characteristic part of the conversion process. Chemicals in **BOLD**	Fibre product	Selected trade names of the fibre or textile	Date of first commercial manufacture, Company & country
Chardonnet silk lustra-cellulose artificial silk; art silk	Cotton linters	Plant cellulose reacted with **nitric and sulphuric acids** and then hydrolysed	Regenerated cellulose after complete hydrolysis[2]	Chardonnet silk	1891 Société de la Soie de Chardonnet, France
Cuprammonium rayon lustra-cellulose glanzstoff; cupro cupra	Cotton linters	Plant cellulose dissolved in aqueous **cuprammonium hydroxide**	Regenerated cellulose	Cupresa; Cuprama Bemberg silk; Bemberger	1900 Vereinigte Glanzstoff Fabriken (VGF), Germany
Viscose rayon	Pine trees; spruce; bamboo[3]	Cellulose reacted with **carbon disulphide** and then hydrolysed	Regenerated cellulose	Lanusa; Tanboocel Fibro; Sarille; Luvisca	1905 Courtaulds, UK
Acetate rayon acetate cellulose diacetate	Pine trees; spruce	Partially reacting the plant cellulose with **acetic anhydride**	Cellulose acetate (mostly as diacetate)	Celanese; Chromspun Estron; Seracata Fibroceta; Aceta	1921 British Celanese, UK
Triacetate	Pine trees; spruce	Fully reacting the plant cellulose with **acetic anhydride**	Cellulose triacetate	Tricel; Courpleta Arnel; Soalon; Lustron	1956 Courtaulds/Celanese, UK
Modal high wet modulus rayon HWM; polynosic rayon	Pine trees; spruce	Viscose **carbon disulphide** process but milder conditions[4]	Regenerated cellulose of higher strength	Toramomen; Tufcel Vincel; Zantrel	*ca* 1956 Tachikawa Research Institute, Japan
Lyocell lyocell viscose; modal micro-modal	Beech trees eucalyptus trees; bamboo[3]	Cellulose dissolved in **4-methylmorpholine *N*-oxide** and wet spun	Regenerated cellulose	Tencel; Excel Ecovero; Livaeco	1988 Courtaulds, UK ('semi-commercial')

1 Provided they can be pre-treated appropriately, other sources of cellulose (*eg* food waste) could be used as starting materials for any of these processes.

2 Cellulose from cotton linters was converted to highly inflammable cellulose nitrate fibres (aka gun cotton!). These fibres then had to be further chemically treated (hydrolysed) to remove the nitro groups and so decrease the flammability. This part of the process would ultimately yield pure regenerated cellulose fibre. There is evidence that this was achieved although probably over a number of years.

3 Bamboo can be converted to fibrous, cellulosic material suitable for spinning without involving any chemical treatments - a laborious, expensive and small-scale process at present. However, many bamboo textiles sold are regenerated cellulose (viscose), made using carbon disulphide. Bamboo can be also used in the Lyocell process.

4 The principal changes adopted to improve wet strength are: no ageing or ripening steps; using weaker acids and alkalis; full stretching of the fibres.

Table 2. Protein-derived fibres (semi-synthetic)

Generic and common names of the fibre. Principal name in **BOLD**	Commonly used starting materials	Characteristic part of the conversion process. Chemicals in **BOLD**	Fibre product	Selected trade names of the fibre or textile	Date of first commercial manufacture, Company & country
Casein fibre[1] milk fibre; azlon[2]	Casein from skimmed milk	Casein in alkaline solution is spun into acid and the fibre hardened with **formaldehyde**	Regenerated protein	Lanital; Aralac Merinova Fibrolane A	1936 Snia Viscosa Italy
Soybean fibre[3] azlon[2]	Soybeans	The protein is extracted, dissolved in alkali and spun into an acid **formaldehyde** bath	Regenerated protein	Silkool; Soyalon Winshow; Soysilk	1938/39[3] Shinko Jinken Co., Japan
Peanut fibre azlon[2]	Protein extracted from groundnuts (peanuts)	Protein in alkaline solution is spun into acid and the fibre hardened with **formaldehyde**	Regenerated protein	Ardil; Sarelon Fibrolane C	1946 (discontinued 1957) ICI Ltd., UK
Maize fibre zein fibre azlon[2]	Zein (a protein) from corn (maize)	**Isopropanol** is used to extract zein from corn meal. The zein is dissolved in alkali, and spun into an acid **formaldehyde** bath	Regenerated protein	Vicara Zycon	1948 (discontinued 1958) Virginian-Carolina Chemical, USA
Casein fibre (modified) azlon[2]	Casein; acrylonitrile (from petrochemicals) ammonia	Casein is reacted with substantial amounts of **acrylonitrile** prior to dissolving in alkali and extrusion	Regenerated protein grafted to polyacrylonitrile	Chinon (K-6) Cyarn[4]; Milvet[4]	1969 Toyobo Co. Japan

1 A casein fibre made without formaldehyde, known as Qmilch, has been under development since 2013, but is not yet in commercial production (2022).
2 Azlon is the generic name for all fibres made from regenerated proteins.
3 Protein fibre from soybeans was also manufactured in 1939-1943 by Glidden Co. and Ford Motor Co. using Shinko Jinken Co.'s patent. In 2003 Shanghai Winshow Soybean Fibre Industry Co., China offered Soysilk and Winshow products.
4 Cyarn and Milvet are recently introduced casein fibres and suspected to be modified with polyacrylonitrile or possibly some other synthetic polymer.

Table 3a Synthetic fibres (introduced 1928–1940)

Generic and common names of the fibre. Principal name in **BOLD**	Commonly used starting materials[1]	Characteristic part of the conversion process. Chemicals in **BOLD**	Fibre product	Selected trade names of the fibre or textile	Date of first commercial manufacture, Company & country
PVC[2,3] chlorofibre; vinyon	Petroleum/ natural gas chlorine	**Ethylene** and **chlorine** are reacted in two stages to give **vinyl chloride** which is polymerised	Poly(vinyl chloride)	Rhovyl; Fibravyl Evilon; Thermovyl	1928 IG Farbenindustrie Germany
Nylon 6.6[4] polyamide	Petroleum/ natural gas	**Hexamethylenediamine** and **adipic acid** are reacted to give the polymer nylon 6.6	Poly(hexamethylene adipamide)	Nylon; Bri-nylon Perlon T; Ban-Lon Antron	1939 DuPont, USA
Nylon 6[4] polyamide	Petroleum/ natural gas	**Cyclohexanone** is converted to **caprolactam** which is then heated to give the polymer nylon 6	Polycaprolactam	Perlon L; Nylon Nylon 6: Kapron	1939 IG Farbenindustrie, Germany
Vinyl chloride-vinyl acetate copolymer[2] chlorofibre; vinyon	Petroleum/ natural gas chlorine; acetic acid hydrochloric acid	**Ethylene** is reacted with **chlorine** in two stages (to form **vinyl chloride**) and then with **acetic acid** (to form **vinyl acetate**). The two monomers are copolymerised	Poly(vinyl chloride-*co*- vinyl acetate)	Vinyon CF Vinyon HH Vinylite; Pulon	1939 American Viscose Co., USA
Saran[2] chlorofibre; vinyon PVDC	Petroleum/ natural gas chlorine	**Vinylidene chloride**, made from **ethylene** and **chlorine**, is polymerised	Poly(vinylidene chloride)	Krehalon; Clorene Tygan; Permalon	1940 Dow Chemical, USA

1 Only the starting materials used today (2022) are shown. However, prior to WW2, coal was the main starting material. After the war, petroleum and natural gas gradually replaced coal. In the 21st century, plant-based alternatives to all fossil fuels are actively being considered as raw materials.
2 PVC, polychloroprene, Saran, vinyl chloride-vinyl acetate copolymer and modacrylic fibres (see Table 3b) have low flammability because of their chlorine content.
3 PVC, when plasticised, is also widely used as a coating for textiles - see Table 4.
4 The number(s) following 'nylon' indicate the raw material used. Nylon 6,6 is made from two components each containing 6 carbon atoms, hexamethylenediamine and adipic acid. Nylon 6 is made from one component of 6 carbon atoms (caprolactam). There are also a few other speciality nylons, similarly named, *eg* nylon 11 (from aminoundecanoic acid which has 11 carbon atoms and is made from castor oil).

Table 3b Synthetic fibres (introduced 1941–1950)

Generic and common names of the fibre. Principal name in **BOLD**	Commonly used starting materials[1]	Characteristic part of the conversion process. Chemicals in **BOLD**	Fibre product	Selected trade names of the fibre or textile	Date of first commercial manufacture, Company & country
Polyurethane[2] **(non-elastic)**	Petroleum/ natural gas	**Hexamethylene 1,6-diisocyanate** and **1,4-butanediol** are reacted to give the polymer	Polyurethane	Perlon U[2]	1941 IG Farbenindustrie, Germany
Acrylic[3] PAN	Petroleum/ natural gas nitrogen (air)	**Propylene** and **ammonia** are reacted to give **acrylonitrile** which is polymerised[3]	Polyacrylonitrile	Orlon; Dralon Acrilan; Courtelle	1948 DuPont, USA
Modacrylic[4] vinyon	Petroleum/ natural gas chlorine	**Acrylonitrile** and **vinyl chloride** are copolymerised	Poly(acrylonitrile-*co*- vinyl chloride)	Dynel; Verel[4]; Teklan Kanecaron Vinyon N; SEF	1949 Carbide and Carbon Chemicals Co., USA
Polyethylene[5] polyolefin; olefin	Petroleum/ natural gas	**Ethylene** is polymerised[5], melt spun and the fibres are then stretched	Polyethylene	Courlene; Sontara Reevon; Tyvek Marlex; Dyneema	1950 Courtaulds, UK
Vinal vinyal; vinylal; PVA; poly(vinyl alcohol)	Petroleum/ natural gas acetic acid	**Vinyl acetate** (from **ethylene** and **acetic acid**) is polymerised and the product hydrolysed to give poly(vinyl alcohol)	Poly(vinyl alcohol)	Kuralon; Vinylon	1950 Kuraray Co., Japan

1 Only the starting materials used today (2022) are shown. However, prior to WW2, coal was the main starting material. After the war, petroleum and natural gas gradually replaced coal. In the 21st century, plant-based alternatives to all fossil fuels are actively being considered as raw materials.
2 Perlon U was a short-lived fibre similar to nylon, discontinued after WW2. However, polyurethanes based on a macroglycol, a diisocyanate and a diamine, provide elastic fibres or coatings, and were developed later - see Elastane, Table 3c.
3 Acrylic fibres are composed of acrylonitrile usually co-polymerised with minor amounts (<15%) of other monomers which provide better properties such as ease of dyeing. However, when the co-monomer content is >15% the fibres are known as modacrylics.
4 Modacrylic fibres together with PVC, polychloroprene, Saran and vinyl chloride-vinyl acetate copolymer have low flammability because of their chlorine content. In some modacrylics, eg Verel, some of the vinyl chloride is replaced by vinylidene chloride which contains more chlorine than vinyl chloride.
5 Polyethylene was originally made by subjecting ethylene to very high pressures; fibres such as Courlene were produced from it. Stronger, higher melting point fibres were later produced at low pressures using special catalysts; the first of these fibres was known as Marlex 50. Later, super strong polyethylene fibres of very high molecular weight, such as Dyneema (DSM) were introduced.

Table 3c Synthetic fibres (introduced 1952–94)

Generic and common names of the fibre. Principal name in **BOLD**	Commonly used starting materials[1]	Characteristic part of the conversion process. Chemicals in **BOLD**	Fibre product	Selected trade names of the fibre or textile	Date of first commercial manufacture, Company & country
Polyester[2,3] PET	Petroleum/ natural gas	**Dimethyl terephthalate** and **ethylene glycol**[3] are reacted to form the polymer	Poly(ethylene terephthalate)	Terylene; Dacron[2] Kodel[3]; Crimplene Lirelle; Fortel	1952 (semi-commercial) [2] ICI, UK
Polypropylene polyolefin; olefin	Petroleum/ natural gas	**Propylene** is polymerised at low pressure	Polypropylene	Meraklon; Ulstron Herkulon; Pylen	1957 Montecatini, Italy
Elastane Spandex (in the USA)	Petroleum/ natural gas	Typically, **tolylene di-isocyanate** is reacted with a **macroglycol** to form a prepolymer. This is then reacted with a **diamine** to give the final polymer	Polyurethane [strictly a poly(urethane-ether-urea) in this example]	Lycra; Spanzelle Dorlastan; Vyrene Blue C; Elura	1959 DuPont US Rubber Co., USA
PTFE fibre[4] fluorofibre	Natural gas (methane) chlorine fluorspar (calcium fluoride) hydrofluoric acid	**Chloroform** and **hydrofluoric acid** are reacted to give **monochlorodifluoromethane**. This is pyrolysed forming **tetrafluoroethylene** which is then polymerised.	Polytetra-fluoroethylene	Teflon; Toyoflon	1965 Toyo Rayon Co. (now Toray Fine Chemicals), Japan
Aramid	Petroleum/ natural gas	Typically **isophthaloyl chloride** is reacted with **benzene-1,3-diamine** to form a polyamide	Polyamide	Nomex; Kevlar	1967 DuPont, USA
Poly(ester-ether) poly(ethylene oxybenzoate) PEB	Petroleum/ natural gas	**Methyl-4-hydroxybenzoate** is reacted with **ethylene oxide** and the product polymerised by heating and the removal of **methano**l	Poly(ester-ether)	A-Tell	1968 Nippon Rayon Co. (now Unitika Co.), Japan
Polylactide PLA	Corn; cassava sugar cane; sugar beet	**Lactic acid** from plant **sugars/ starches** is converted to the **cyclic dilactide** which is polymerised by heating and melt spun	Polylactide poly(lactic acid)	Lactron; Ingeo; Lacty Ecodear; Terramac	1994 Kanebo Gohsen Ltd., Japan

1 Only the starting materials used today (2022) are shown. However, prior to WW2, coal was the main starting material. After the war, petroleum and natural gas gradually replaced coal. In the 21st century, plant-based alternatives to all fossil fuels are actively being considered as raw materials.
2 Polyester fibre was patented by The Calico Printers' Association in the UK in 1941. The patent was sold to ICI who developed the fibre as Terylene in the UK and by 1952 limited quantities had been sold. By 1953, under licence from ICI, DuPont had established full commercial production of polyester fibre in the USA, calling it Dacron.
3 Polyester fibre was also made in the USA by Eastman Kodak using 1,4-cyclohexanedimethanol in place of ethylene glycol and sold under the name Kodel in 1958.
4 See also PTFE membrane, Table 4.

Table 4. Selected non-fibrous synthetic polymers used in clothing[1]

Generic and common names of the polymer material. Principal name in **BOLD**	Commonly used starting materials[2]	Characteristic part of the conversion process. Chemicals in **BOLD**	Typical polymer end product	Trade names of the polymer material	Date of first commercial manufacture, Company & country
Polychloroprene[3]	Petroleum/ natural gas chlorine	**Butadiene** is treated with **chlorine** and then partially dechlorinated to give **chloroprene** which is then polymerised	Polychloroprene[3] interlayer	Neoprene; Duprene Baypren	1931 DuPont, USA
PVC coating[4] vinyl; leathercloth pleather	Petroleum/ natural gas	**Ethylene** and **chlorine** are reacted in two stages to give **vinyl chloride** which is polymerised. A plasticiser such as **diisononyl phthalate** is then mixed with the polymer	Poly(vinyl chloride) coating	Rexine; Koroseal Vinoflex	1932 B.F. Goodrich, USA
Styrene-butadiene rubber SBR; GR-S	Petroleum	**Butadiene** and **styrene** in ratio 3:1 are copolymerised	Poly(butadiene-*co*- styrene) coating or interlayer	Buna S; Buna SB Chemigum-S Hycar-OS; Pliolite	*ca* 1935 IG Farbenindustrie, Germany
Polyurethane coating[5] PU leather	Petroleum/ natural gas	Typically **4,4'-diphenylmethane diisocyanate** and a **macroglycol** are reacted to give the polymer	Polyurethane coating	Perlon U[5] Insqin; Desmopan	1941 IG Farbenindustrie, Germany
PTFE membrane[6] polytetrafluoro-ethylene	Natural gas chlorine fluorspar (calcium fluoride)	**Chloroform** and **hydrofluoric acid** are reacted to give **monochloro-difluoromethane**. which on pyrolysis yields **tetrafluoro-ethylene**, a gas which is then polymerised. On stretching the polymer rapidly, a porous membrane is formed.	Polytetrafluoro-ethylene interlayer	Gore-Tex; Teflon	1976 W. L. Gore & Associates Inc., USA

1 The polymers in this table are used in the form of films, either as fabric coatings or interlayers.
2 Only the starting materials used today (2022) are shown. However, prior to WW2, coal was the main starting material. After the war, petroleum and natural gas gradually replaced coal.
3 Polychloroprene is widely used for wet suits. It has good fire-resistance.
4 PVC fibres were first made commercially in 1928, but *plasticised* PVC was discovered later by Waldo Semon at B.F. Goodrich in 1932. Also note PVC fibre (Table 3a).
5 Polyurethanes are diverse polymers, originally invented in 1941 at IG Farbenindustrie. Perlon U is a fibre, whereas Insqin is a polyurethane dispersion for coating textiles.
6 Also note PTFE fibre (Table 3c).

2.6 Blended fibres

What are blended fibres? Many of the documented garments in section 5 are made from two or more different fibres which have been blended to create a single yarn. The blended fibres may have different physical properties, for example cotton and polyester which together form the most widely used commercial blend in the textile industry, or be different versions of the same fibre, such as the standard (non-shrinkable) and retractable (shrinkable) acrylic fibres used to make fake fur.

Yarns made of different fibres and fibre blends are also used structurally. In a woven fabric one yarn might form the warp and another the weft. There are many historical precedents for this practice. In the eighteenth century, the fabrics called fustians included a plain weave material woven with a linen warp and cotton weft, and by the 1820s the use of cotton warps in the British wool textile industry was widespread.

Benefits of blended fibres: the purpose of combining two or more fibres as a mixture or blend is to take advantage of the positive characteristics of the component parts. The aim is to improve the overall performance, aesthetic appearance, texture and consistency of the yarns and fabric; reduce the manufacturer's exposure to risk, particularly in the supply chain, and ensure profitability; meet changing consumer preferences, and develop new products.

Blending processes: design and technology play key roles in the blending process.

The method used to create semi and fully synthetic fibres results in the production of continuous filaments (see section 2.2). Silk is the only traditional natural fibre of filament form. All other natural fibres are relatively short fibres of differing lengths which require spinning and twisting together to create yarn lengths. These fibres are called staple fibres. Semi and fully synthetic fibres are also transformed into staple fibres by cutting the filaments. Staple fibre viscose rayon, which was commercially available in the UK from 1925, was the first man-made staple fibre. It is manufactured by cutting the filament fibre into short lengths before spinning and twisting together to make staple yarn. Staple fibres were integral to the development of blends because the most efficient way to mix different fibres is during the process of making a yarn. Blended yarns may be composed of different staple fibres, or staple fibres combined with filament fibres. Similarly, different yarns and filaments can be twisted together to create a complex yarn.

The ratios between the different fibres in a blend depends on their physical characteristics, tenacity and extension at break, and the required characteristics of the end product.

The method used to combine the fibres, and degree of blending, ranges from the highest possible homogeneity of mixing between the fibres in the final yarn ('intimate blending') to a yarn which twists together fine yarns of different fibres to create a blended yarn rather than mixing the fibres at the spinning stage (a marl yarn).

2.7 Finishes and coatings for garments

The coating and finishing of synthetic fibres during garment production grew out of natural fibre manufacture, with new synthetic materials increasing the range of possibilities. Finishing applications with synthetics are designed to improve fibre properties and performance, like water-proofing treatments for viscose rayon and cotton.

Lubricants: have an important role in reducing fibre friction in natural and synthetic yarn and thread manufacture. They are also effective anti-static agents applied as after-treatments to fabrics made with cellulose triacetate, nylon, polyester, acrylic and Dynel (modacrylic, composed of vinyl chloride-acrylonitrile copolymers) in fur and piled fabrics. These fibres readily acquire electric charge that they hold onto as static. Its control serves two important consumer purposes. One is reducing attraction of lint, small airborne particulates and dirt. This makes it easier to care for the fabric. Another is to protect the wearer from little electric shocks, sparks and crackles released from static build-up and lessen the discomfort of 'slippery' and 'sticky' static fabrics that make garments move and misalign around the body. There is also an aesthetic reason. Lubricants help to maintain the 'fullness' of synthetic furs and piled fabrics.

Binding media: synthetic polymers are used as binding media for pigments in textile printing and coloured surface finishes.

Textile coating techniques: there are many ways of applying coatings including:

- Direct coating, in which the coating is spread on the material with a fixed knife.
- Spray coating, in which the coating is sprayed directly on the textile by a variety of different ways.
- Extrusion coating, in which the coating is passed through a sheet die and transferred directly onto the textile.
- Foamed coating, normally used for knitted and woven textiles, in which a foam coating lies on the surface of the textile and is then pressed onto the textile by a roller.

Artificial leather: known under many names, including leatherette, imitation leather, faux leather, vegan leather, PU leather, and pleather is produced using a fabric base layer, which is coated using rollers and given the texture and appearance of real leather. The chemical coating can be made from either polyurethane or PVC. It is commonly used in jackets, shoes, gloves, hats, pants, belts, watch bands, and handbags.

2.8 Fibres in complex garment structures

The structure of some garment types, for example tailored jackets, can be highly complicated with multiple layers of construction. The garment label seldom provides their details, but they will include synthetics, especially in linings and interfacings.

Linings:

- Main body linings: from the 1920s onwards, rayon is used as a cheaper alternative to silk.
- Sleeve linings: they need to be smooth to help the jacket sleeve slide on and off. An apprentice tailor's exercise book of 1962 belonging to Melville Hopwood states that rayon is the best material to use for sleeve linings.
- Pockets: the material for pockets needs to be extremely hardwearing. Nylon is a particularly strong material and is often used either on its own or as a reinforcement for cotton or rayon to give extra strength.

Interfacings: this is the layer between the outer fabric and the lining, which is used in tailoring to give strength and structure. Examples include the canvas forepart, which shapes and strengthens the front of a jacket and lapel padding. A Burton Tailoring booklet dating from the late 1950s lists 47 different component parts used in the construction of a jacket. Interfacing components were traditionally made of strong natural fibres such as horsehair, wool and linen. The introduction in the late 1950s and 1960s of synthetics allowed for many new developments. They could be used either on their own or blended with natural fibres to give interlinings added strength and a more permanent shape. For example, a 1961 copy of *The Tailor and Cutter*, a trade magazine, includes an advertisement for 'Crossair — a super resilient nylon interfacing to make the best fronts and lapels.'

In tailoring, hand stitching is traditionally used to hold the interfacings in place. Fusible interfacings offer an alternative method of attachment. A fusible interfacing is a textile, either natural or synthetic, woven or bonded, which is chemically treated on one or both sides to provide adhesion on the application of heat. The use of heat and glue in a fusible interfacing, rather than stitching, speeded up the tailoring construction process. Fusible interfacings began to appear in the 1960s. Melville Hopwood discusses the advantages of fusible interfacings in his tailoring exercise book which dates to 1962.

Interlinings: is a lining often found in coats sewn between the ordinary lining, as described above, and the outside fabric. They are used for extra warmth and the introduction of synthetic fibres enabled interlinings to provide waterproofing. These interlinings are sometimes breathable, preventing the wearer from getting wet and becoming too warm or cold. Interlinings can be blended from synthetic and natural fibres. Brands like Aquascutum, Mulberry and Burberry often use interlinings for their outerwear ranges.

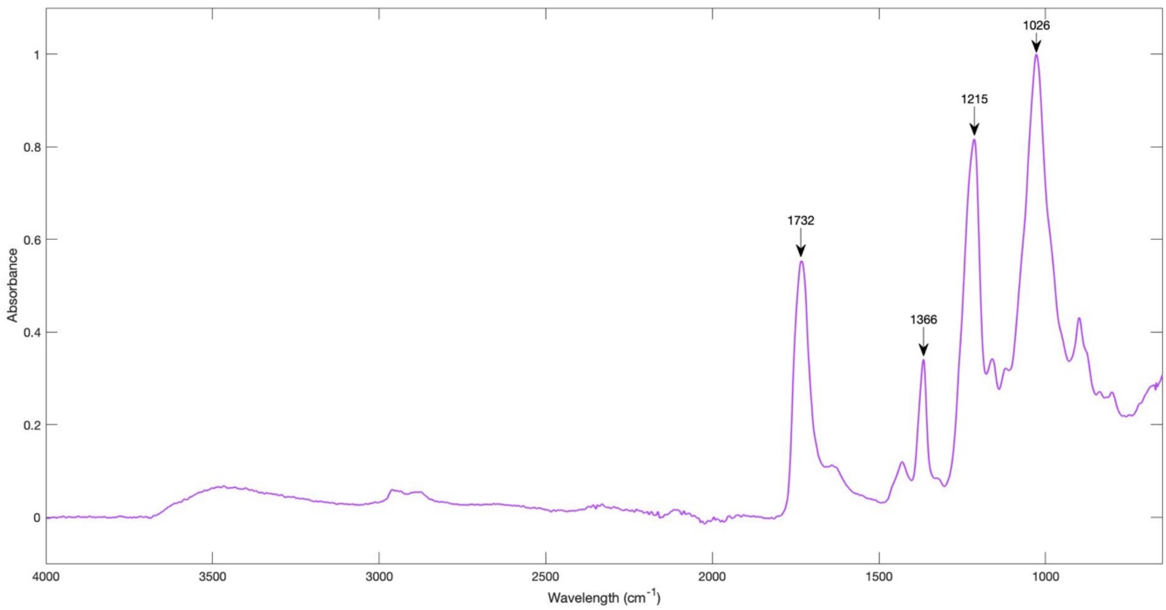
3. Featured fibres and materials

This section brings together information about each of the fibres/materials used to make the garments which are documented in section 5. It includes their inventors (when this is known), when they were manufactured in commercial quantities, a selection of the most common trade names, commonly used starting materials, their material characteristics, uses, environmental impact, care and signs of degradation, recyclability, biodegradability, and potential narratives related to them.

The materials are arranged in alphabetical order based on their most used generic name. Other common names are listed on the following line. The trade names in this section and the tables in section 2.5 Fibres at a glance are not arranged in any order. For more information about the FTIR spectra please see 4.1 Fibre Identification: FTIR spectroscopy. It is very difficult to find accurate dates for their introduction and we decided to omit them to avoid misleading inaccuracies.

Acetate Rayon: see section 5 Documented garment exemplars: 5; 6; 11

Acetate; cellulose diacetate; cellulose acetate



Inventors (of manufacturing process)**:** Charles Frederick Cross (1855–1935) and Edward John Bevan (1856–1921)
Patented: 1894
Commercially available from: 1921, British Celanese, UK
Trade names: Celanese; Seraceta; Fortisan; Chromspun; Estron
Commonly used starting materials: cotton linters and later wood pulp derived from pine trees and spruce, most recently bamboo. For a simplified visual explanation of the process from starting materials to usable fibre see Section 2.3 Fibre conversion processes: acetate rayon.
Principal characteristics: soft and warm handle with a smooth surface; drapes well; does not shrink; quick drying but unstable in high heat; moth resistant; low tensile strength and weaker when wet; unsuitable for garments which are subject to hard wear; vulnerable to mould in high humidity.

Principal uses: in the 1920s and 1930s popular for women's woven and knitted underwear, blouses and sweaters. Today promoted as a luxury fibre, widely used as a silk substitute for satins and taffeta because of its lustrous surface. More body and better draping qualities than viscose rayon, making it popular for dress and lining materials.
Environmental impact: the wood pulp may be sourced from forests which are not managed sustainably, and from endangered ancient forests. Bamboo is often grown as a monocrop harming the local ecosystem.
Care and signs of degradation: so far observation leads us to believe it is a relatively stable fibre. Because it attracts water, it is vulnerable to mould in damp conditions, thus relative humidity should not exceed 70%. Must be laundered with care either by hand-washing or dry cleaning. Acetate rayon garments disintegrate when heated in a dryer.
Recyclable? Yes, by mechanical recycling. Chemical recycling is potentially possible.
Biodegradable? Cellulose is biodegradable, however the rate at which cellulose acetate biodegrades is affected by the degree of acetylation of the cellulose during its manufacture and the environment in which the process takes place.
Potential narratives:

- The importance of semi and fully synthetic fibres to the underwear and nightwear industries.
- Development of different types of viscose fibres.

Acrylic: see section 5 Documented garment exemplars: 10; 14; 20; 22; 33

PAN, Polyacrylonitrile

Inventor: Dupont
Invented: 1941
Commercially available from: 1948, USA
Trade names Acrilan; Orlon; Courtelle; Dralon
Commonly used starting materials: petroleum; natural gas; nitrogen (air)
Principal characteristics: quite stretchy; soft to the touch; lightweight; quick drying with high moisture wicking abilities; low breathability, highly insulating, thus very warm; stains easily unless given a surface finish; highly flammable; prone to pilling and static.

Principal uses: often used instead of wool as a knitting material and thus in sweaters and gloves. Also found in hoodies and tracksuits and used to make fake fur.
Environmental impact: depletion of fossil fuels, a non-renewable resource, due to the high-energy requirement for acrylonitrile production and its chemical origins in oil and gas. Use of toxic chemicals and volatile substances that can harm the environment if not handled carefully. Acrylic fibres are very prone to pilling. When washed, acrylic fibres enter the water system as microfibres causing pollution. These fibre fragments are difficult to filter and recycle.
Care and signs of degradation: so far observation leads us to believe it is a relatively stable fibre. Its predisposition to static is increased when air humidity is low: thus, relative humidity levels as a general guide should not drop below 40%. Conservation-grade covers should be used to protect against static attraction of dust.
Recyclable? Yes, and unlike many synthetic materials, it can be recycled in a way that prevents the materials from degrading. This means the process does not require the input of new materials. However, it is accepted by very few recycling contractors.
Biodegradable? No
Potential narratives:

- Environmental impact: use of non-renewable resources, toxins, microfibres.
- Substitute for wool, arguably protecting animals from harm, thus a vegan material.

Aramid: see section 5 Documented garment exemplars: 29; 39

Inventor: Stephanie Kwolek (1923–2014), Dupont
Invented: 1964
Commercially available from: 1967, USA
Trade names: Nomex; Kevlar
Commonly used starting materials: petroleum; natural gas
Principal characteristics: lightweight; outstanding strength-to-weight ratio, with a tensile strength equivalent to steel; good resistance to abrasion; very high melting point, low flammability.
Principal uses: protective clothing, for example bullet proof vests and fireproof suits.
Environmental impact: depletion of fossil fuels, a non-renewable resource. Sulphuric acid is one of the main chemicals used it its production. Sulphuric acid is very toxic to animals and plants and dangerous unless the correct controls are in place.

Care and signs of degradation: so far observation leads us to believe it is a relatively stable fibre.
Recyclable? Yes, it is 100% recyclable and can be used multiple times. There are firms that specialise in its recycling.
Biodegradable? No
Potential narratives:

- substitute for steel.
- a technical textile which extends the potential of what has been possible and saves lives.
- women in science.

Casein fibre: see section 5 Documented garment exemplars: 43

Milk fibre; azlon (azlon is the generic name for all fibres made from regenerated proteins)

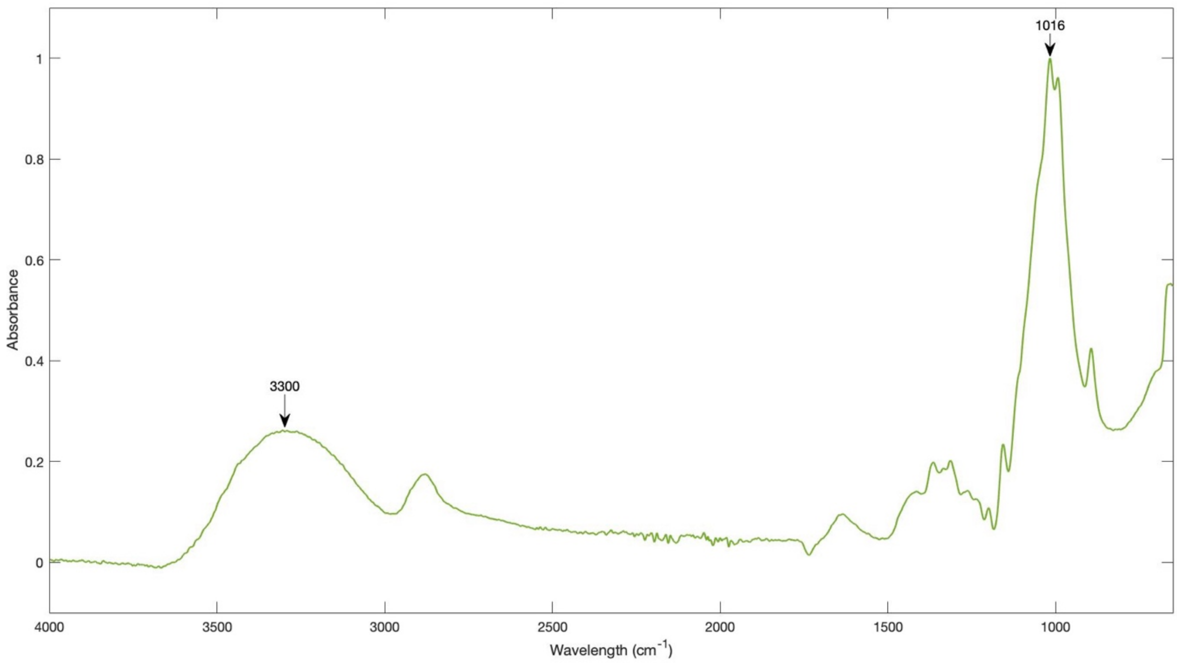
Inventor: Antonio Ferretti (1889–1955)
Patented: 1935
Commercially available from: 1936, Snia Viscosa, Italy
Trade names: Lanital; Aralac; Merinova; Fibrolane A; Chinon K-6 (modified casein fibre)
Commonly used starting materials: Casein from skimmed milk; and for modified casein fibre: acrylonitrile (derived from petrochemicals) and ammonia. For a simplified visual explanation of the process from starting materials to usable fibre see Section 2.3 Fibre conversion processes: casein fibre.
Principal characteristics: soft, with a warm handle; good thermal insulation; light and comfortable to wear with a silky feel; it readily attracts water, making it vulnerable to mould in damp conditions when relative humidity exceeds 70%; in its original form it had poor wet strength.
Principal uses: initially developed as a wool substitute. Today it is often blended with other fibres and used for underwear and clothes worn against the skin. Global production is very small, and the fibre is expensive.
Environmental impact: depletion of fossil fuels, a non-renewable resource, due to the high-energy requirement for acrylonitrile production. Use of toxic chemicals and volatile substances that can harm the environment if not handled carefully. More positively, the fibre uses waste milk which would otherwise be poured away.

Care and signs of degradation: casein fibres are susceptible to microbiological growth. They accept dyes well but have poor wash-fastness. Casein fabrics need to be stored at a relative humidity level above 40%. Lower relative humidity can result in brittleness and breakage of fibres.
Recyclable? Potentially. Acrylic, which is also made with acrylonitrile, can be recycled in a way that prevents the materials from degrading. This means the process does not require the input of new materials. However, it is accepted by very few recycling contractors.
Biodegradable? Yes, when it is made with formaldehyde**.** No, if made with acrylonitrile.
Potential narratives:

- research into the production of alternative fibres as substitutes and in the pursuit of sustainability.
- the politicisation of textiles: the use of Italian manufactured milk protein fibre as a nationalist symbol by the Italian fascists in the late 1930s and during World War Two is an interesting example of this.

Cuprammonium rayon: see section 5 Documented garment exemplars: 3; 4

Lustra-cellulose; glanzstoff; cupro, cupra



Inventor: Louis Henri Despeissis (d.1892)
Patented: 1890 (lapsed); 1897 (Dr. Hermann Pauly on behalf of Max Fremery and Johann Urban)
Commercially available from: 1900
Trade names: Bemberg silk; Bemberger; Cupresa; Cuprama
Commonly used starting materials: cotton linters
Principal characteristics: feels and looks silky and smooth; can be manufactured with very fine fibres; drapes well; quite stretchy; easy to dye and absorbs colour well; breathable with moderate moisture wicking and heat retention qualities; anti-static and machine washable; prone to pilling; chars when it burns and leaves a coppery residue.

Principal uses: from the 1920s, when the properties of cuprammonium had been improved, it became popular for stockings and underwear. During World War Two it was used for parachute cloth in Germany and USA. Today it is utilised for light weight garments such as lingerie, blouses, evening wear and linings.
Environmental impact: Cuprammonium is a by-product of the cotton industry which unless the plants are farmed organically, requires intensive irrigation and the application of chemical fertilisers, pesticides and herbicides. This can impact on local drinking water supplies and expose workers, those living in the vicinity of the cotton fields and the environment to land, water and air pollution. Cotton farming is also associated with exploitation, of farmers and farm labourers who include children and forced labour. Using the cotton linters to make cuprammonium utilises waste but further toxic chemicals are involved in the fibre's production. Its manufacture was halted in the United States in 1974 because it contravened US Environmental Protection Agency regulations. Today, closed loop manufacturing processes are used but the responsible disposal of the waste that can no longer be recycled remains an issue. There are no ecological certifications for cuprammonium.
Care and signs of degradation: so far observation leads us to believe it is a relatively stable fibre.
Recyclable? Yes, by mechanical recycling.
Biodegradable? Cuprammonium is biodegradable under optimum conditions, but the process may be inhibited by the chemicals used to dye and finish the fabric.
Potential narratives

- how research and development for one industry can benefit another. The manufacturing technology used to create cuprammonium fibres was developed from the technology originally used to create electric light bulb filaments.
- the social, political and ethical issues of global textile production.

Elastane: see section 5 Documented garment exemplars: 9; 28; 34; 38; 39; 41; 42

See also Polyurethane below
Spandex (USA)

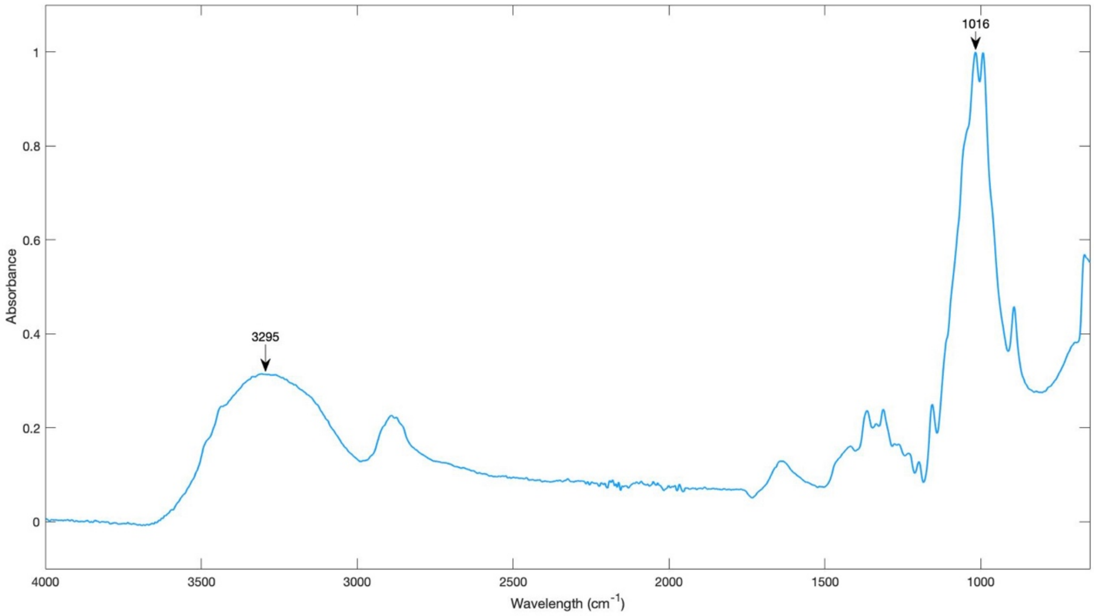
Inventor: Joseph Shivers (1920–2014), DuPont
Invented: 1958
Commercially available from: 1959 DuPont, USA; US Rubber Co., USA

Trade names: Spandex; Lycra; Spanzelle; Dorlastan; Vyrene; Blue C; Elura
Commonly used starting materials: petroleum; natural gas
Principal characteristics: contains at least 85% polyurethane organised in rigid and flexible segments; excellent stretch and recovery which enables good shape retention, the higher the percentage of elastane in a garment the closer and firmer the fit; high breathability, moderate heat retention
Principal uses: stretchy, form fitting clothing: sportwear, close fitting jeans, leggings, tights and socks, foundation garments and underwear. Today small percentages are found in many materials and garments from knitwear to dress fabric.
Environmental impact: made from non-renewable resources in a chemical heavy process. Sheds micro-plastics. Its environmental impact is compounded by the amount produced each year and the fact that it is not biodegradable.
Lycra® is currently developing a range of more sustainable fabrics incorporating varying types and percentages of recycled materials. These fabrics include Lycra®EcoMade fibre which is manufactured from 20% factory waste blended with virgin polymer, Lycra®T400®EcoMade fibre, which is made from 50% recycled PET and 18% plant content blended with virgin polymer, and Lycra® Xtra life™. For Lycra® Xtra life™, please see section 4, object no. 41
Care and signs of degradation: can stiffen and become misshapen, so supported handling and careful mounting for display is particularly important, with attention to minimising flex at seams, areas weighted with metal zips, beads and suchlike. Further degradation of particularly "valuable" garments made of Lycra can be prevented by using oxygen-free storage. This, however, reduces access, increases storage space requirements and has to be repeated.
Recyclable? Difficult to recycle, but recycling of Spandex is undertaken by Spanflex, Taiwan.
Biodegradable? No
Potential narratives:

- impact on fashion.
- sculpting of the human body and ensuing impact on sport.
- how one brand is responding to the demand for more sustainable products.

Lyocell: see section 5 Documented garment exemplars: 28; 32

Lyocell viscose; Tencel™ branded modal



Inventor: Clarence C. McCorsley III patented the process, but the method had been subject to research and development from the 1960s

Invented: 1981, US patent granted to McCorsley

Commercially available from: 1988, Courtaulds, UK (semi-commercial production); 1992, Courtaulds, Mobile, Alabama, USA

Trade names: Tencel; Excel; Ecovero; Livaeco

Commonly used starting materials: beech and eucalyptus trees, bamboo. For a simplified visual explanation of the process from starting materials to usable fibre see Section 2.3 Fibre conversion processes: lyocell.

Principal characteristics: very versatile, can be manufactured to look and feel like silk, cotton and wool; high tensile strength; soft with excellent draping qualities; receptive to dyes and colour-fast; breathable and moisture wicking; medium risk of pilling.

Principal uses: fashion, sportswear; often used for its sustainable credentials.

Environmental impact: the lyocell fibre spinning process is an environmentally responsible green technology that eliminates toxic chemical use and chemical reactions, recycles and re-uses over 90% of the dissolving agent in a closed loop process. The leading producers use wood pulp from sustainably managed, plantation grown, fast-growing trees, including eucalyptus which will grow in very dry conditions. However, if the wood pulp is derived from non-sustainable sources, it would be an issue.

Care and signs of degradation: lyocell is an extremely stable fibre with high moisture absorption and antibacterial properties.

Recyclable? 100% lyocell fabric has the potential for re-use and remanufacture; blended fabrics are problematic and cannot be commercially recycled at present.

Biodegradable? Yes

Potential narratives:

- benefits and challenges of introducing circular systems to textile production.
- sustainable design.

Modacrylic: see section 5 Documented garment exemplars: 14

Vinyon

Inventor: unknown

Patented: unknown

Commercially available from: 1948, Carbide and Carbon Chemicals Co. (later known as Union Carbide), USA. Until 1960, when the US Federal Trade Commission placed modacrylic in its own category, it was classed with acrylic.

Trade names: Vinyon; Dynel; Verel; Teklan; Kanecaron; Vinyon N; SEF

Commonly used starting materials: petroleum; natural gas; chlorine

Principal characteristics: low flammability; low moisture absorbency and quick drying; outstanding resistance to chemicals and solvents; resistant to moths, mildew and sunlight; soft, warm and resilient but prone to pilling.

Principal uses: used in high-performance and protective clothing. Also used for nightwear, fleeces and as a substitute for fur.

Environmental impact: made from a combination of non-renewable resources, some of which are carcinogenic. Creates microfibres.

Care and signs of degradation: so far observation leads us to believe it is a relatively stable fibre. It is, however, prone to pilling and matting.

Recyclable? Yes

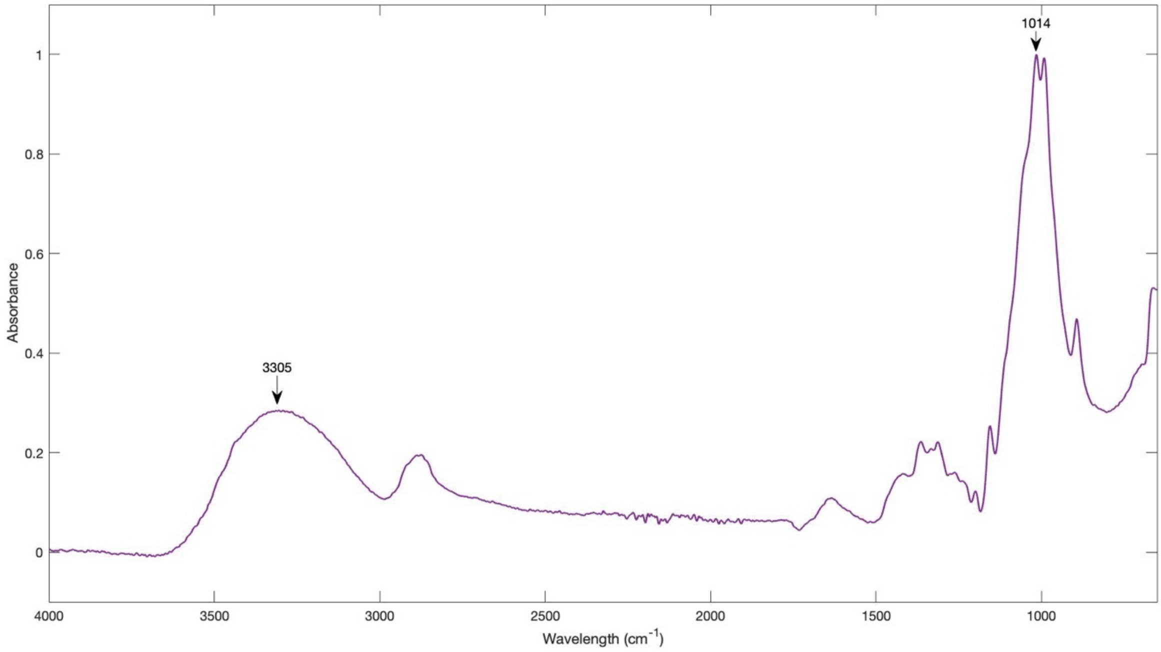
Biodegradable? No

Potential narratives:

- rare use in fashion: in 1968, fashion designer Pierre Cardin (1922–2020) used Dynel fabric (which he marketed as ‘Cardine’) to make a collection of heat-moulded dresses.
- occupational health hazards.

Modal: see section 5 Documented garment exemplars: 39

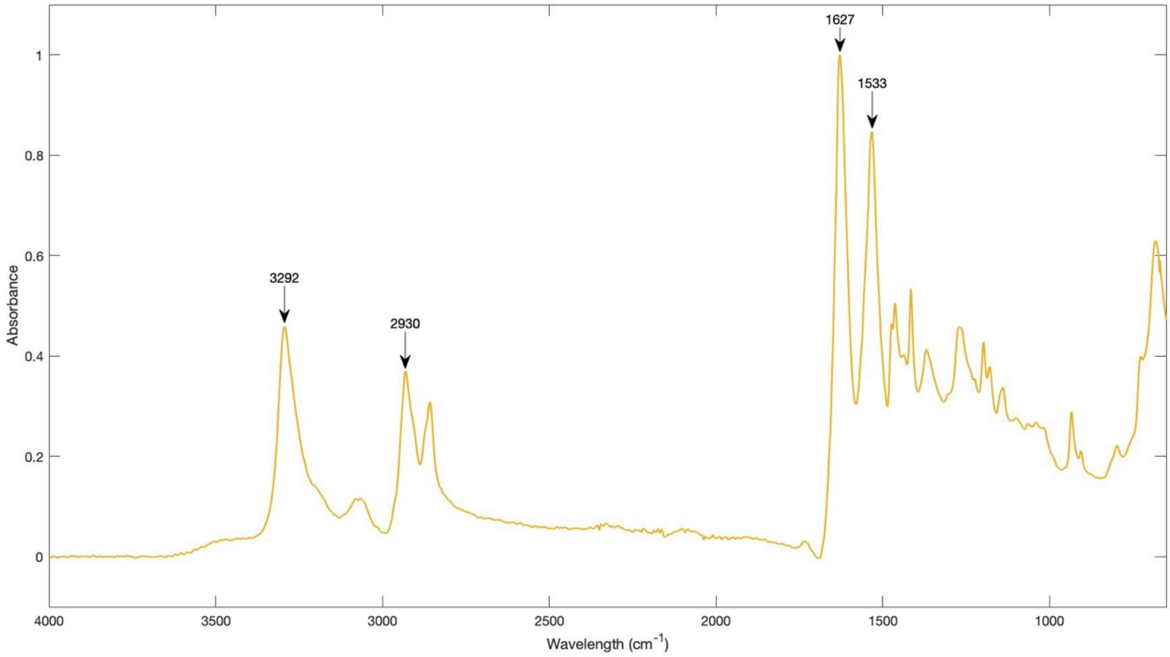
High wet modulus rayon (HWM), polynosic rayon



Inventors: S. Tachikawa, Japan
Invented: 1951 (US patent applied for)
Commercially available from: *circa* 1956 Tachikawa Research Institute, Japan
Trade names: Toramomen; Tufcel; Vincel; Zantrel
Commonly used starting materials: pine trees, spruce
Principal characteristics: high breathability, moisture-wicking abilities; low heat retention; not prone to pilling; can be laundered in a low temperature 'delicates' wash; air dry.
Principal uses: alternative to silk or cotton. Used for sportswear, underwear and T-shirts.
Environmental impact: the wood pulp may be sourced from forests which are not managed sustainably and from ancient and endangered forests. However some manufacturers have FSC (Forest Stewardship Council)-certification, meaning that the wood used to make the viscose fibres came from responsibly managed, fully traced forest plantations and are therefore guaranteed not to contribute to illegal deforestation. The manufacturing process is slightly more environmentally friendly than that of viscose rayon, but, if the correct precautions are not followed, factory discharges can cause air, land and water pollution. The production process also results in less waste than that of viscose rayon.
Care and signs of degradation: so far observations lead us to believe it is a relatively stable fibre.
Recyclable? Yes
Biodegradable? Yes
Potential narratives:

- the development of viscose production.
- attitudes to materials capable of imitating natural materials.

Nylon: see section 5 Documented garment exemplars: 9; 13; 15; 16; 18; 19; 21; 23; 24; 26; 27; 28; 29; 30; 31; 35; 37; 38;41; 42
Polyamide



Nylon has several variants such as nylon 6 and nylon 66. As fibres, they are similar (see Table 3a) and both are used for textiles, nylon 66 perhaps more frequently. However, as is common practice, in this section we use the name nylon without suffix.

Inventor: Wallace Carothers (1896–1937), DuPont

Patented: 1935

Commercially available from: 1939, DuPont, USA

Trade names: Nylon; Perlon; Ban-Lon; Bri-nylon; Antron

Commonly used starting materials: petroleum; natural gas. For a simplified visual explanation of the process from starting materials to usable fibre see Section 2.3 Fibre conversion processes: nylon.

Principal characteristics: strong, durable and lightweight; washes easily, wrinkle resistant and waterproof; prone to pilling and static; cheap.

Principal uses: very versatile, thus it can be found in a wide variety of garments including windcheaters, sportswear, lingerie, and hosiery. It is used where strength is required, for example in pockets (see section 2.8. Fibres in complex garment structures).

Environmental impact: made from non-renewable resources in a chemically heavy process. Cyanides used to make the intermediate adipic acid are highly toxic. Its production results in the release of nitrous oxide, a greenhouse gas that makes a significant contribution to global warming. Nylon sheds microfibres and is among the largest causes of microplastic pollution in the oceans.

Care and signs of degradation: its predisposition to static is increased when air humidity is low: thus, relative humidity levels as a general guide should not drop below 40%. Inclined to stretch under load, so supported handling and careful mounting for display is particularly important, with attention to minimising flex at seams, areas weighted with metal zips, and suchlike. Ideally such garments should be stored flat. Conservation-grade covers should be used to protect against static attraction of dust. Tendency to discolour and turn yellow.

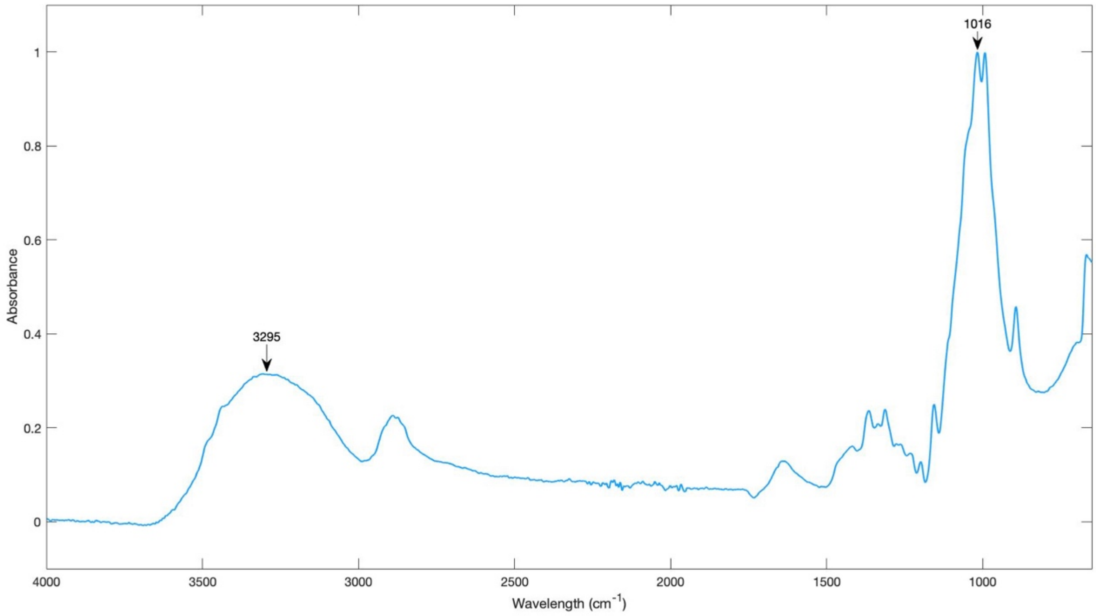
Recyclable? Yes, Econyl, for example, is a certified recycled nylon textile.

Biodegradable? No
Potential narratives:

- recycling.
- what the world would be like without nylon: how nylon fabric contributes to everyday life.
- hazards associated with the material.

Orange fiber: see section 5 Documented garment exemplars: 40

See also Viscose rayon below



Inventors (of pulp production process): Adriana Maria Santanocito and Elena Vismara
Patented: 2014 (filed)
Commercially available from: at the time of writing, Orange Fiber SRL is still in the research and development phase with limited commercial production supporting special capsule collections, with, for example, Salvatore Ferragamo in 2017, H&M Conscious Exclusive Collection in 2019 and E. Marinella in 2021
Commonly used starting materials: citrus waste (rind, skin, pith) from industrial juicing
Principal characteristics: silk-like appearance and soft to the touch; to date used blended with silk, cotton and elastane and, most recently, manufactured by Lenzing in a process that mixes orange and wood pulp to create a limited edition Tencel™ branded lyocell fibre.
Environmental impact: made from locally sourced citrus juice industry leftovers, which would otherwise be discarded as waste. Can be produced in an environmentally responsible closed loop process.
Care and signs of degradation: Potentially vulnerable to mould in damp conditions, thus relative humidity should not exceed 70%.
Recyclable? Not known.
Biodegradable? Yes
Potential narratives:

- women in science.
- utilisation of agricultural and food industry waste to make textile fibres.
- challenges of scaling new products to achieve full commercial production.

Polychloroprene: see section 5 Documented garment exemplars: 36

Neoprene

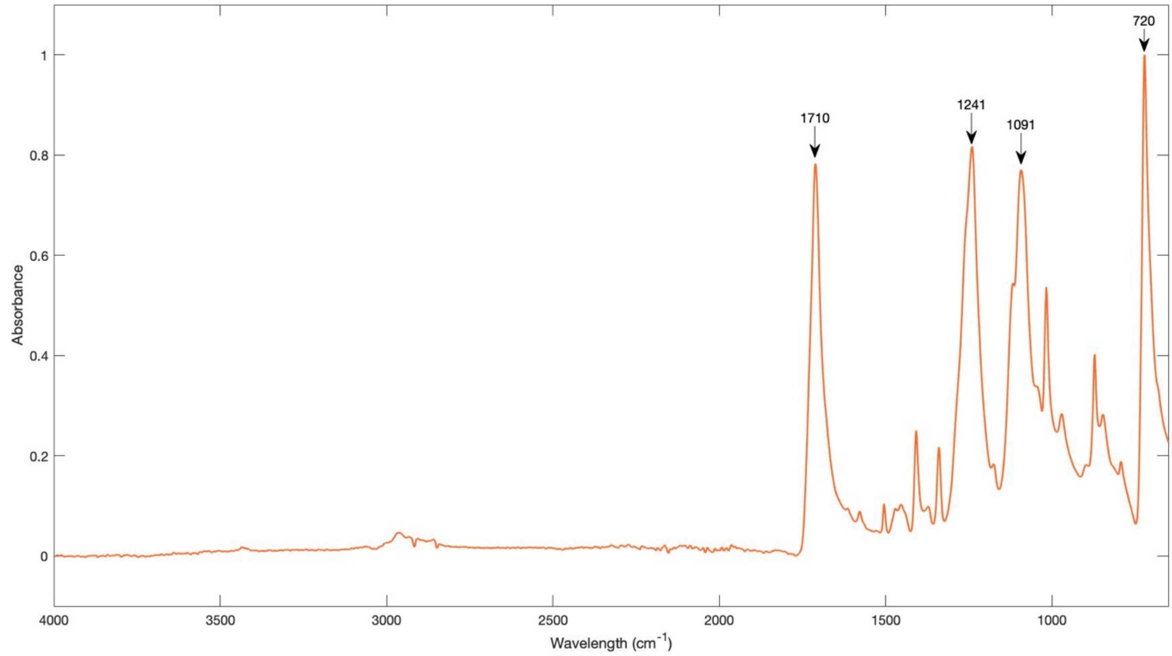
Polychloroprene is a synthetic rubber. It is included here because it is widely used for wetsuits and other items of clothing, especially as an interlayer sandwiched between fibrous materials.

Inventors: Arnold Collins (1899–1992) and Wallace Carothers (1896–1937), DuPont, USA
Invented: 1930
Commercially available from: 1931, DuPont, USA
Trade names: Duprene; Neoprene
Commonly used starting materials: petroleum; natural gas; chlorine
Principal characteristics: as a synthetic rubber its uses are similar to natural rubber, but it is more resistant to water, solvents, heat and fire; known for its insulating qualities; expensive
Principal uses: wet suits and clothing protecting against fire. Also used as an interlayer sandwiched between fibrous materials. Today increasingly used for fashion.
Environmental impact: made from non-renewable resources in a chemically heavy process.
Care and signs of degradation: less prone to degradation than natural rubber, but degrades fast when exposed to ultraviolet.
Recyclable? Yes, but not every recycling facility will take it as the process is different from that most frequently used.
Biodegradable? No
Potential narratives:

- substitute for traditional materials (rubber): pros and cons.
- impact on sport, especially wetsuits used for surfing and snorkelling.
- value as a life-saving material compared with its inherent toxicity.

Polyester: see section 5 Documented garment exemplars: 12; 16; 18; 21; 24; 26; 31; 32; 34; 37

PET



Inventors: Rex Whinfield and J. T. Dickinson
Invented: 1941
Commercially available from: 1952, ICI Ltd. UK (semi-commercial production); 1953, DuPont USA
Trade names: Terylene; Dacron; Kodel; Crimplene; Lirelle; Fortel; Sil-Look
Commonly used starting materials: petroleum; natural gas. For a simplified visual explanation of the process from starting materials to usable fibre see Section 2.3 Fibre conversion processes: polyester.
Principal characteristics: cheap to produce; durable, multi-purpose; hydrophobic and crease-resistant; quick drying, requires no ironing; warm to the touch; moth and mildew proof; prone to pilling and static.
Principal uses: clothing of all kinds. Particularly used for drip dry, non-iron shirts, fleeces, as well as garments and accessories exposed to water. Used in blends, especially polycotton blends.
Environmental impact: made from non-renewable resources. Dangerous substances involved in its manufacture include antimony which is likely to remain within the product but if released would have serious consequences. Newer catalysts for polyester employ titanium compounds which have much less environmental impact. Sheds microfibres.
Care and signs of degradation: its predisposition to static is increased when air humidity is low: thus, relative humidity levels as a general guide should not drop below 40%. Conservation-grade covers should be used to protect against static attraction of dust.
Recyclable? Yes
Biodegradable? No
Potential narratives:

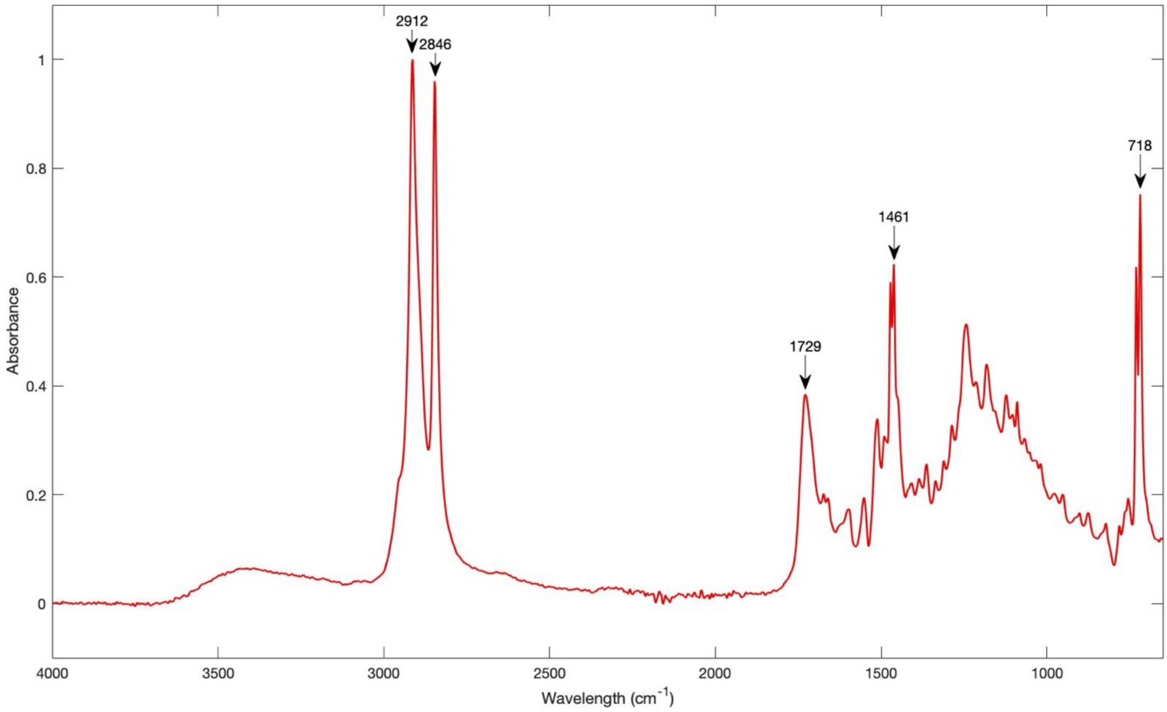
- good material for research into blends, especially in tailoring where their use was more about improvements than their cheapness.
- one of the most used fibres in clothing production: study of its impact.
- the generation and impact of microfibres: a study by Plymouth University published in 2020 discovered that one 40°C wash could release between 700 and 4,000 microfibres per gram

of fabric depending on its structure, and that up to 400 microfibres per gram of fabric can be shed in 20 minutes of normal activity when wearing polyester clothing.

- the introduction of easy care, drip dry, non-iron fabrics and its impact on women's lives.

Polyethylene: see section 5 Documented garment exemplars: 27

polyolefin; olefin

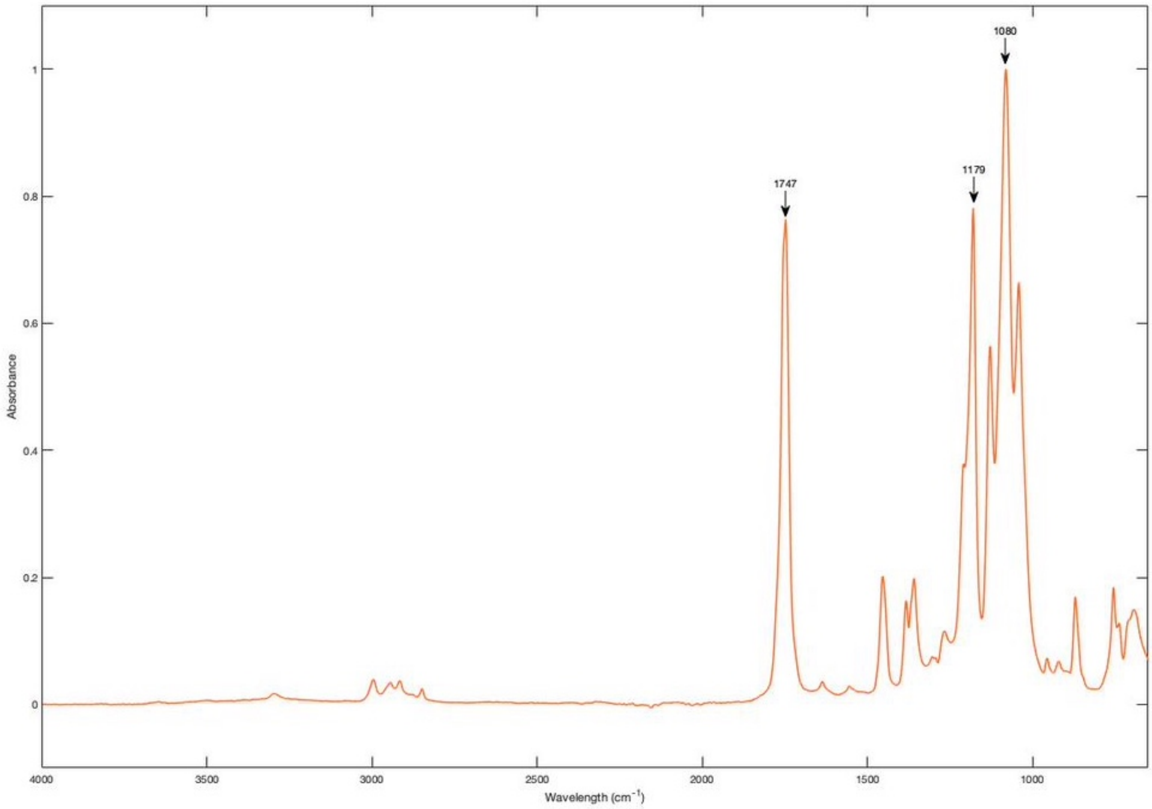


Inventors: Eric Fawcett and Reginald Gibson, ICI Ltd. UK
Invented: 1933
Commercially available from: 1950s, UK
Trade names: Courlene; Sontara; Reevon; Tyvek; Marlex; Dyneema
Commonly used starting materials: petroleum; natural gas
Principal characteristics: very strong; resistant to chemical corrosion, weathering and abrasion; fluid repellent; good electrical insulating properties
Principal uses: as a bonded fabric for protective clothing, surgical gowns, belts. Commonly used for garment covers and other purposes by museum and heritage collections.
Environmental impact: made from a non-renewable resource in a high energy process whose emissions generate air pollution.
Care and signs of degradation: Polyethylene fabrics may yellow over time. This is generally due to the inclusion of additives such as optical brighteners in the fabrication process. It is advisable to store these materials in a cool, dark environment.
Recyclable? Yes
Biodegradable? No
Potential narratives:

- history of protective clothing and how synthetic fibres have transformed them.
- a good material through which to look at the issues surrounding recycling.

- improvements in the properties of synthetic fibres over time and the role of research and development.

Polylactide: no documented garment exemplars.



Inventor: discovered by Wallace Carothers (1896–1937), 1932
Patented:
Commercially available from: 1994, Kanebo Ghosen Ltd., Japan
Trade names: Lactron (said to be the first commercial polylactide fibre), Ingeo, Ecodear, Terramac
Commonly used starting materials: corn, cassava, sugar cane, sugar beet. For a simplified visual explanation of the process from starting materials to usable fibre see Section 2.3 Fibre conversion processes: polylactide.
Principal characteristics: good wicking qualities; UV resistant; can be blended with traditional natural fibres; good shape retention and resistance to creasing; can be utilised for wadding; can be washed in warm water but only pressed with a cool iron; low melting point makes dyeing and finishing challenging.
Principal uses: used as a sustainable alternative to oil and gas-based polymers. Currently being developed for apparel.
Environmental impact: made from annually renewable crops of carbon-absorbing plants in a process that does not involve solvents.
Care and signs of degradation: Polylactide appears to be very stable and does not require specialised care. Unlike other synthetic fibres, it does not absorb light in the visible region of the spectrum. This leads to very low strength loss compared to petroleum-based fibres when exposed to ultraviolet light. It does, however, have lower colour fastness than synthetics like PET.
Recyclable? Yes, in a chemical recycling facility. Chemical recycling is not yet commercially available.

Biodegradable? Yes, in an industrial composting plant. In landfill or a domestic composting system it decomposes very slowly.

Potential narratives:

- use of fermentation in the development of bio-based fibres.
- the pros and cons of replacing fossil fuel derived polymers with polymers derived from plants, including agricultural waste.

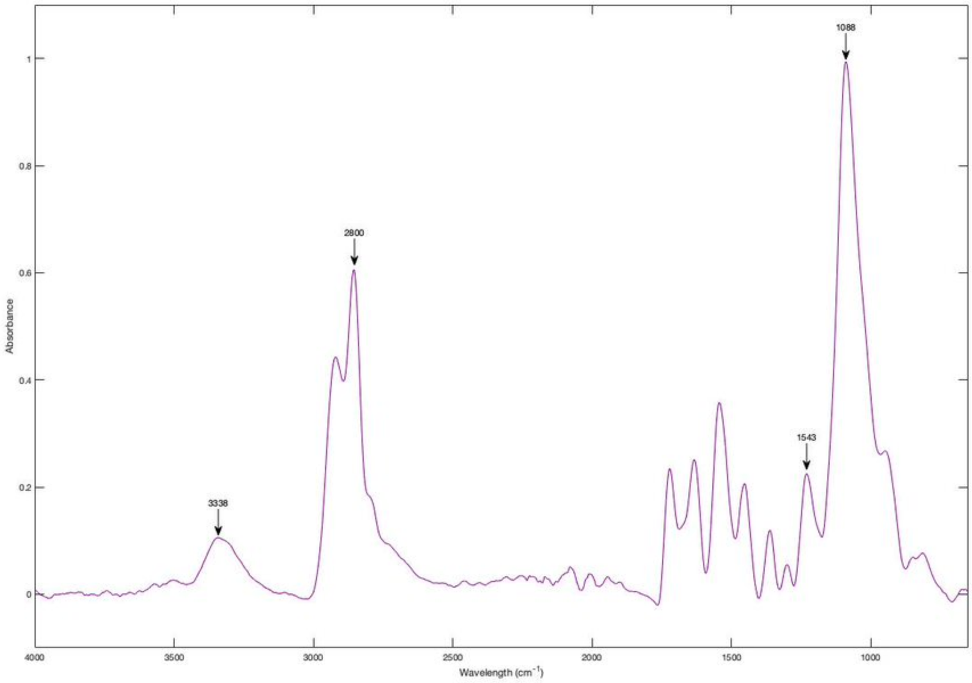
Polynosic rayon: see section 5 Documented garment exemplar: 39

High wet modulus rayon, modal

Inventors: S.Tachikawa, Japan
Invented: 1951
Commercially available from: c.1956Tachikawa Research Institute, Japan
Trade names: Toramomem; Tafcel; Vincel; Zantral
Commonly used starting materials: pine trees, spruce
Principal characteristics: high breathability, moisture-wicking abilities; low heat retention; not prone to pilling
Principal uses: alternative to silk or cotton. Used for; sportswear, underwear, T-shirts.
Environmental impact: the wood pulp may be sourced from forests which are not managed sustainably and from ancient and endangered forests. However some manufacturers have FSC (Forest Stewardship Council)-certification, meaning that the wood used to make the viscose fibres came from responsibly managed, fully traced forest plantations and are therefore guaranteed not to contribute to illegal deforestation. The manufacturing process is slightly more environmentally friendly than that of viscose rayon mainly because less concentrated caustic soda is used to dissolve and purify the cellulose. However, if the correct precautions are not followed, factory discharges can cause air, land and water pollution. The production process also results in less waste than that of viscose rayon.
Care and signs of degradation: so far observations lead us to believe it is a relatively stable fibre.
Recyclable? Yes
Biodegradable? Yes
Potential narratives:

- the development of viscose production.
- attitudes to materials capable of imitating natural materials.

Polyurethane: see section 5 Documented garment exemplars: 33, 35, 42
PUR, PU



Inventors: Otto Bayer (1902–82), Farbenindustrie, Germany
Invented: 1937
Commercially available from: 1941, I G Farbenindustrie. Germany
Trade names: Perlon U
Commonly used starting materials: petroleum; natural gas
Principal characteristics: lightweight, waterproof, with high buoyancy and breathability; sometimes flexible; resistant to mould, mildew and pests
Principal uses: initial use was as a short-lived fibre similar to nylon. Ongoing use as a fabric coating for imitation leather, sportswear and industrial clothing. Closely related to elastane (see above).
Environmental impact: made from a non-renewable resource in a high energy process. However, it has significant uses beyond the textile industry fostering sustainability as for example in the insulation of buildings
Care and signs of degradation: Migration of plasticisers to the surface can lead to the garment becoming sticky. Removal of this sticky material is only a temporary solution as more of the plasticiser will migrate eventually leading to brittleness. Thus, polyurethane garments are best stored wrapped in silicon release paper to avoid adhesion enclosed in either acid-free costume boxes or encased in calico slings/covers in a cool environment.
Recyclable? Yes
Biodegradable? No
Potential narratives:

- contribution to technical textiles for specialist situations.
- animal welfare: substitute for leather.

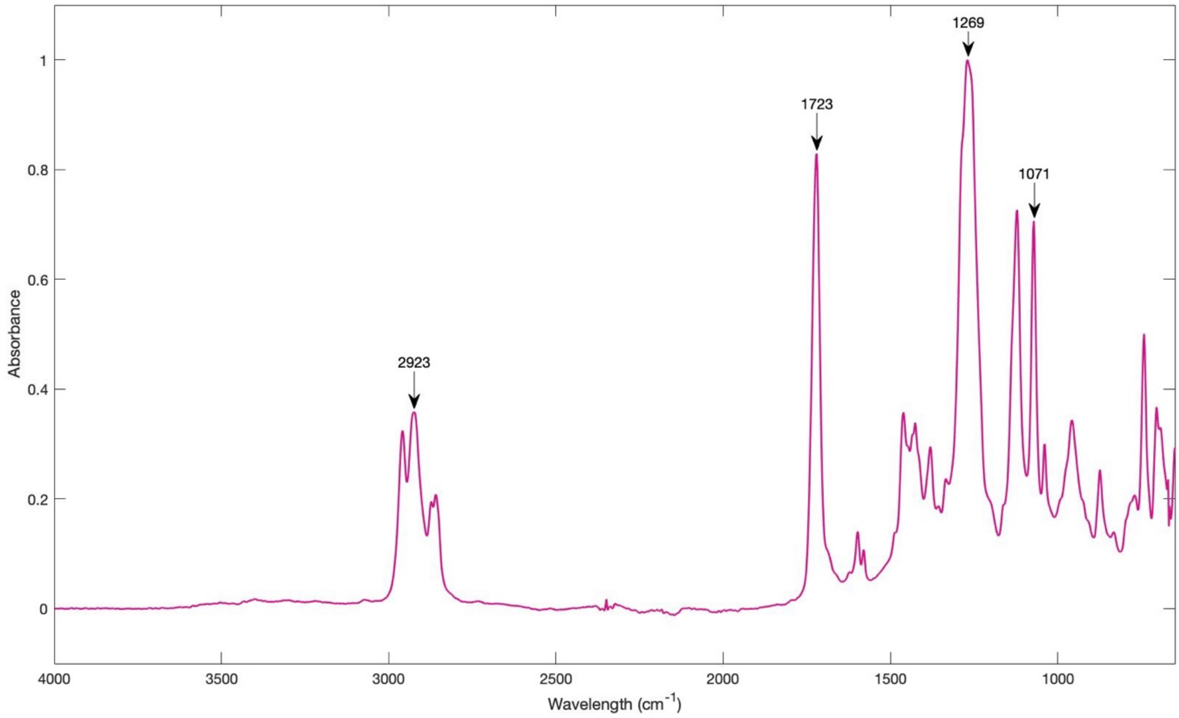
PTFE membrane: see section 4.2 Documented garment exemplars: 23

Polytetrafluoroethylene membrane

Inventor: Robert Gore
Invented: 1969
Commercially available from: 1976, W. L. Gore & Associates
Trade name: Gore-Tex
Commonly used starting materials: natural gas, chlorine, fluorspar
Principal characteristics: lightweight, waterproof, with high breathability. Resistant to mould, mildew and pests.
Principal uses: as a breathable membrane interlayer for waterproof clothing**.**
Environmental impact: made from a non-renewable resource in a high energy process using a highly toxic chemical (hydrofluoric acid).
Care and signs of degradation: The membrane is stable and strong. No special care needed.
Recyclable? No
Biodegradable? No
Potential narratives:

- Versatility of some polymers; in this instance PTFE as membrane, fibre, engineering plastic or non-stick coating for cooking utensils.

PVC (Polyvinyl chloride): see section 5 Documented garment exemplars: 31
Chlorofibre; vinyon

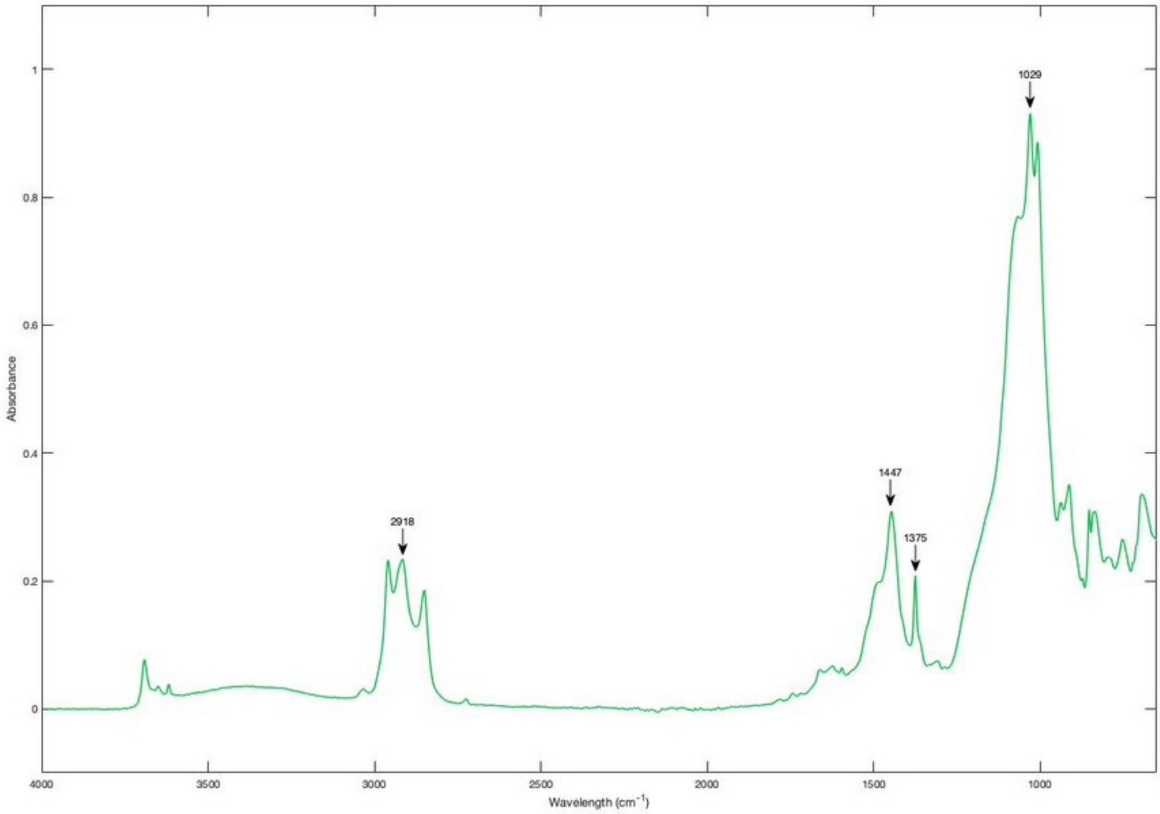


Inventor: Waldo Semon (1898–1999), 1926 (Semon was the first to invent material uses for PVC)
Patented: 1913, Friedrich Klatte (1880–1934)
Commercially available from: 1928 IG Farbenindustrie, Germany
Trade names: Rhovyl; Fibravyl; Evilon; Thermovyl
Commonly used starting materials: petroleum; natural gas; chlorine
Principal characteristics: flame-resistant; waterproof; crease resistant; soft and comfortable with good insulation properties
Principal uses: protective clothing, for example for astronauts, fire fighters and the military; rain wear; sportswear; fashion, including as a substitute for leather; often used as a coating for other materials.
Environmental impact: made from and manufactured with non-renewable resources; unregulated production causes toxic emissions and water pollution; toxic additives such as cadmium and lead are widely used as stablilisers and phthalates as plasticisers; the safe disposal of PVC is an issue.
Care and signs of degradation: has the propensity to develop a sticky surface due to the migration of plasticisers from within the bulk of the material. This has historically caused problems such as the adhesion of dust and wrapping materials. PVC textiles and coated fabrics (Pleather) should be wrapped using silicon release paper to avoid adhesion and stored enclosed in either acid-free costume boxes or encased in calico slings/covers in a cool environment.
Recyclable? The high chlorine content and presence of hazardous additives in less regulated products make recycling very problematic
Biodegradable? No
Potential narratives:

- substitute for leather, arguably protecting animals from harm, thus a vegan material
- relative environmental impact throughout their life cycle of animal versus PVC products in fashion

Styrene-butadiene rubber see section 5 Documented garment exemplars: 25

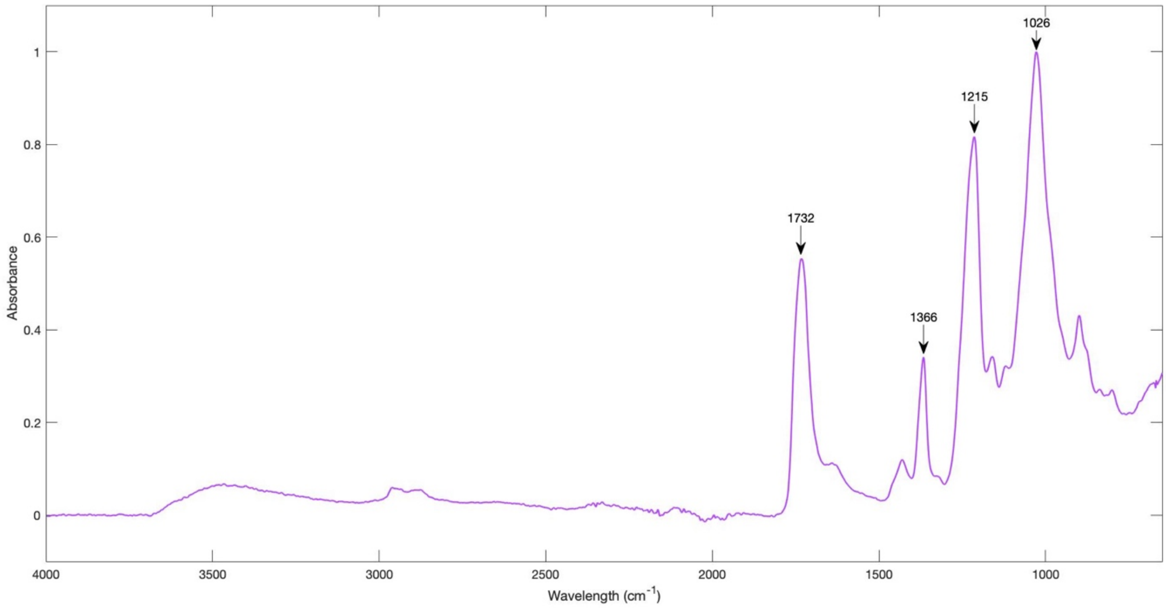
Styrene-butadiene rubber; SBR



Inventors: Eduard Tschunkur (1895–1948) and Walter Bock (1874–1946), Germany
Invented: 1929
Commercially available from: *circa* 1935 by IG Farbenindustrie, Germany; from 1942 by Firestone, Goodyear, US Rubber Co., and Goodrich, USA
Trade names: Buna SB, Buna S, GR-S, Chemigum-S and Hycar-OS
Commonly used starting materials: petrochemicals (coal when first manufactured)
Principal characteristics: similar to natural rubber; good abrasion resistance, impact strength, and resilience; high tensile strength; cheap
Principal uses: Where abrasion resistance is required, for example car tyres.
Environmental impact: made from non-renewable resources. Increases greenhouse gas emissions. Acts as pollutant in landfill.
Care and signs of degradation: so far observations lead us to believe it is a relatively stable material.
Recyclable? Yes
Biodegradable? No
Potential narratives:

- contribution to technical textiles for specialist situations.
- industry creation.
- relationship between natural and synthetic materials.
- World War Two substitute for unavailable natural rubber.

Triacetate: see section 5 Documented garment exemplars: 19

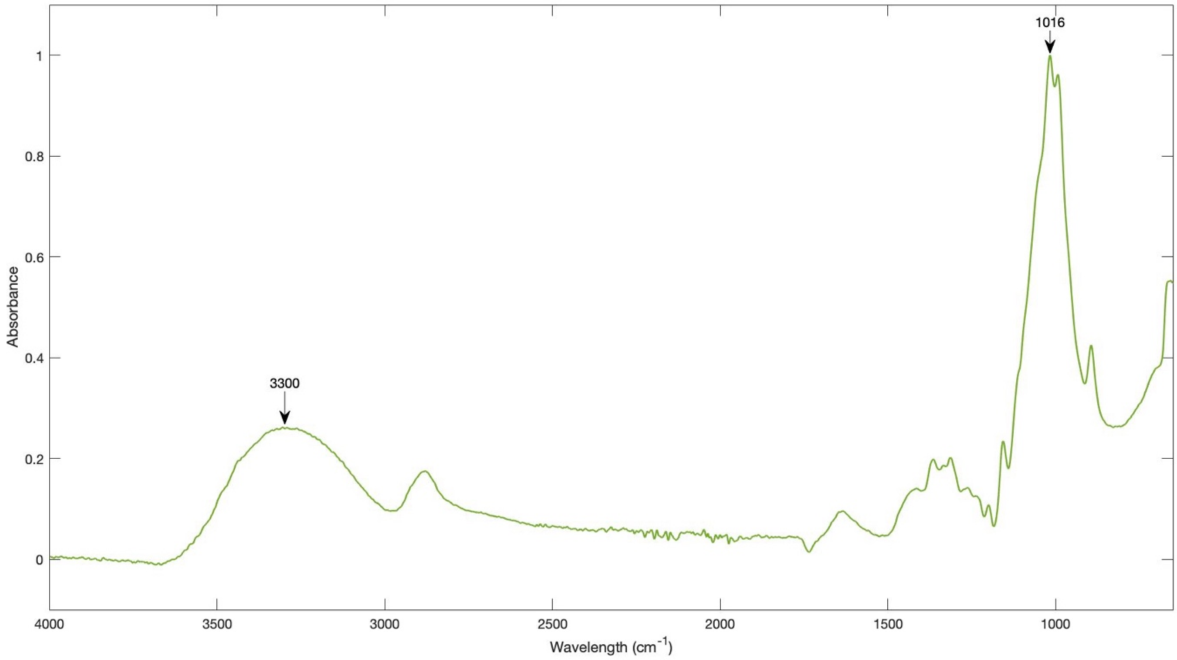


Inventors: Paul Schützenberger first prepared cellulose acetate in 1865**;** Charles Frederick Cross (1855–1935) and Edward John Bevan (1856–1921) developed a manufacturing process in 1894
Patented: 1894
Commercially available from: 1956, Courtaulds/Celanese, UK
Trade names: Tricel; Courpleta; Arnel; Soalon; Lustron
Commonly used starting materials: pine trees, spruce
Principal characteristics: lightweight, drapes well with a smooth, silky texture; resistant to shrinking, fast drying; can be heat set into pleats and treated to resist wrinkles; non-iron but can be pressed at a medium heat; resistant to moth and mildew; prone to static.
Principal uses: as a fashion fabric and for everyday clothing.
Environmental impact: the wood pulp may be sourced from forests which are not managed sustainably, and from endangered ancient forests.
Care and signs of degradation: prone to static especially when air humidity is low. For this reason, relative humidity levels as a general guide should not drop below 40%. Conservation-grade covers should be used to protect against static attraction of dust.
Recyclable? Yes, by mechanical methods; chemical recycling is also potentially possible.
Biodegradable? Cellulose is biodegradable, however the rate at which cellulose acetate biodegrades is affected by the degree of acetylation and the environment in which the process takes place.
Potential narratives:

- challenges of recycling cellulosic and cellulose-derived semi-synthetic textiles.

Viscose rayon: see section 5 Documented garment exemplars: 1; 2; 5; 7; 8; 10; 11; 15; 17; 18; 39; 40; 43

See also Orange fiber viscose above.



Inventors: Charles Frederick Cross (1855–1935), Edward John Bevan (1856–1921) and Clayton Beadle (1868–1917)

Patented: 1892

Commercially available from: 1905, Courtaulds UK

Trade names: Lanusa; Tanboocel; Fibro; Sarille; Luvisca

Commonly used starting materials: pine trees, spruce, bamboo. For a simplified visual explanation of the process from starting materials to usable fibre see Section 2.3 Fibre conversion processes: viscose rayon.

Principal characteristics: initially distinguished by its high sheen which led to comparisons with silk and to the fibre being marketed as 'artificial silk'; soft with good draping qualities; moisture wicking; loses about 50% of its strength when wet and dry cleaning is recommended; polynosic (modal) or high wet modulus rayon commercially available in 1956 addressed this problem.

Principal uses: very versatile. First marketed for braids and trimmings. Luvisca, a mixed fabric woven with a cotton warp and viscose weft was sold from 1908. All-viscose cloth followed and knitted stockings in 1912. Early products included shirts, blouses, underwear, pyjamas, jumpers and sports coats. De-lustred and textured rayon yarns, developed in the 1920s and 1930s, increased the fibre's potential and popularity as a fashion fibre. An important fibre during World War Two used for many utility garments. Widely used today for clothing.

Environmental impact: the wood pulp may be sourced from forests which are not managed sustainably and from ancient and endangered forests. However, some viscose manufactures have FSC (Forest Stewardship Council)-certification, meaning that the wood used to make the viscose fibres came from responsibly managed, fully traced forest plantations and is therefore guaranteed not to contribute to illegal deforestation. Some manufactures are using waste streams as the raw material for viscose production, such as Orange Fiber Viscose (see below). Discharges, especially of carbon disulphide, from factory can cause air, land and water pollution.

Care and signs of degradation: so far observations lead us to believe it is a relatively stable fibre. Its hygroscopic nature makes it vulnerable to mould in damp conditions so relative humidity should not exceed 70%.

Recyclable? Yes, by mechanical methods.

Biodegradable? Viscose rayon is biodegradable under optimum conditions, but the process may be inhibited by the chemicals used to dye and finish the fabric.

Potential narratives

- the launch of the man-made fibre industry in the twentieth century made chemistry central to the production of textile fibres with established chemical businesses such as DuPont (USA), ICI (Britain) and I. G. Farbenindustrie (Germany) playing leading roles.
- the new man-made fibres expanded the range of fibres available to designers and, once they were fully commercialised and accepted by the public, created more affordable and diverse fabrics
- stockings: from viscose to nylon and spandex. (NB. Cuprammonium also used to make stockings in the 1920s.)

4. Curatorial process

4.1 Acquisition

Most institutions have collecting policies which define the scope of the existing collections and describe the criteria for processes such as acquisition, storage, preservation, transfer and disposal. Every acquisition should be able to tell several stories and have a clear role within the institution's programme and activities. For some ideas about the narratives which can be told through semi and fully synthetic garments, see section 6 Potential narratives and research areas.

There is a predisposition towards acquiring objects whose storage needs are understood and can be met, and whose longevity is known. As this guide makes clear we are only just beginning to undertake research to establish how synthetic fibres and fabrics behave over time and their life span. We can offer general guidelines about appropriate temperature and humidity ranges for objects in storage and on display and some fibre specific information. See section 4.5 Caring for synthetic garments, and the entries on individual fibres in section 3 Featured fibres and materials.

There are occasions when a conflict arises between a material's potentially short lifespan or unknown behavioural patterns and a legitimate proposal to acquire an example to document its historical, social, and cultural connotations. This dilemma will become more acute as new materials made in novel ways come on the market, for instance those designed to meet the challenge of climate change. Contemporary collecting is an important aspect of developing and enhancing the relevance of our collections for present and future audiences. We need to be open to discussing how such objects could be registered, cared for, studied, and made accessible within the museum.

4.2 Good documentation practice

Semi-synthetic and fully synthetic garments present documentation problems not shared with garments made from traditional natural materials.

Fibre identification: the identification of fibres, without materials labels, is very difficult indeed, and even labels cannot always be trusted. Identification methods which are 100% reliable depend on scientific analysis (see section 4.4 Fibre identification: FTIR spectroscopy). Unfortunately, this method is not an option for many museums. We hope that the tips given in section 4.4 combined with the information about the different fibres in section 3 Featured fibres and materials, and 5 Documented garment exemplars, will provide useful guidance.

It is unrealistic to think that every fibre will be identified. If you are unable to pinpoint the fibre but are confident that it is synthetic, the term 'synthetic' can be used. Qualifying a fibre with 'probably' or 'possibly' is also helpful. The adverbs make it clear that the identification is not scientifically proven but is an educated guess on the part of the writer. When the fibre can be identified, the part of the garment made from it should also be recorded.

The use of fibre blends in garments, which are often a combination of natural and synthetic fibres (see section 2.6 Blended fibres), and the application of finishes and coatings, such as waterproofing, during a garment's production (see section 2.7) can add confusion. The complex structure of some garments means that not all the fibres involved can be seen and touched (see section 2.8). Thus, while it is desirable to identify and record the materials in a garment in as much depth as is possible, it is likely that often it will not be possible to identify them all, or even some. In these cases, their presence should be documented in the description of the object. Even if you know what the fibre is, it can be difficult to decide what to call it. We have opted for what we believe to be the clearest of their most used generic names, as given in bold in the first column of the tables in section 2.5 Fibres at a glance.

Country of production: different parts of garments may be made in different countries. We believe the country specified on a garments label is the final country involved in the production chain.

Labels: these can be extensive, and attention should be paid to them although the information they provide may not be accurate. We recommend describing the type of label, whether woven or printed and where it is sewn into the garment. Card labels should be retained. Ideally all labels should be transcribed and, if it is the case, their translation into multiple languages noted. It is good to identify the languages if possible.

Methods: this field has four parts: fibre manufacture, yarn manufacture, fabric construction and garment construction. For information about how semi and fully synthetic fibres and yarns are manufactured see sections 2.2 Fibre creation and 2.6 Blended fibres. It is perfectly acceptable to qualify a method with 'possibly' or 'probably' or simply to say 'unknown' and move on. Documentation is an on-going process. Further research and new technologies may resolve these questions.

Measurements: synthetic garments are prone to stretching thus taking measurements can be problematic. A single measurement of the most useful dimension of the garment is desirable. It should be stated from where the measurement is taken.

4.3 Dating garments

Whether a garment is made of natural or synthetic materials, valuable information about its date can be gleaned from its cut, style and fastenings, the colour(s) and/or pattern(s) of its principal materials, and the trimmings used to embellish it.

Labels: there are several types of labels which can assist dating: manufacturers and retailers' labels, fibre and care labels, and size labels. They can provide evidence collectively and individually with the result measured against the date suggested by the material and aesthetic characteristics of the garment. (For a summary of the regulations governing fibre and care labels, and their use in practice, see section 4.4 Fibre and care labels. For an in-depth study of sizing and information on size labels, see section 8.1 Bibliography and other resources, Dating.)

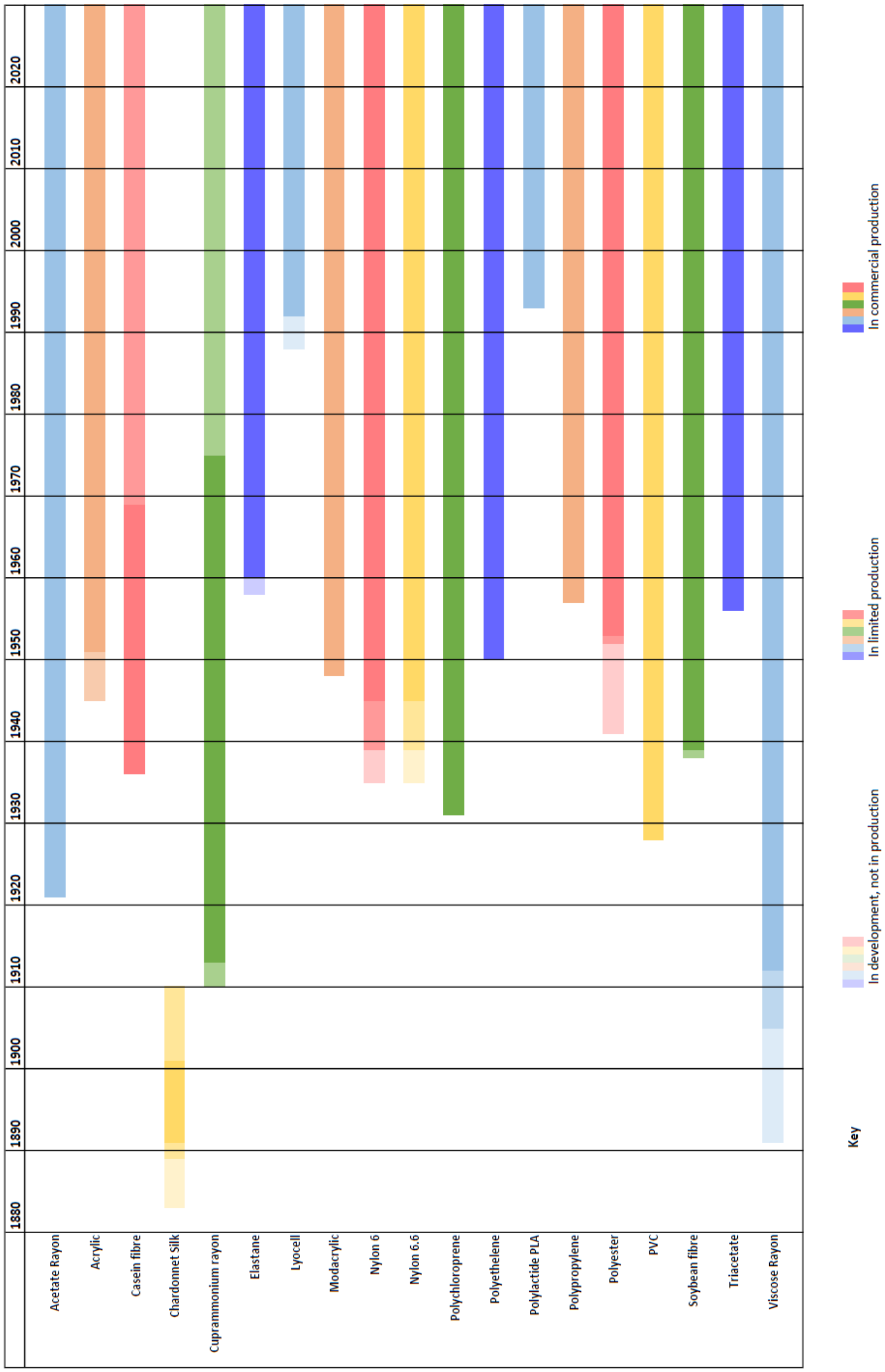
Manufacturers and retailers' labels can be very useful, particularly when they include an address which has the potential to be traced using trade and telephone directories, and on-line company records. The label's design and its font can also be indicative. However, it is wise to be cautious. Labels with out-of-date addresses sometimes continued to be used as an economy measure after a move to new premises, and a manufacturer or retailer might retain or adopt a historical font as part of their branding.

Occasionally labels are only used for a specific length of time. The British wartime Utility label (for clothing, September 1941–March 1952) is a good example. The first Utility clothes, (clothes made from cloth produced under the Utility scheme), labelled CC41, went on sale in 1942.

Size labels: these indicate that a garment is ready-made. Men's sizes reflect single body parts, such as the neck (for shirts), chest (for a sweater) and waist (for trousers), with today the possible addition of length of leg. Women's sizes are generally an aggregate of the bust, waist and hip measurements or for bras, based on the bust size in inches, qualified with an indication of cup size by some companies from the mid-1930s.Size labels for women's clothing evolved as the women's ready-made industry became more established in the decades after the end of World War One in 1918 and manufacturers introduced more stock sizes. At first dress sizes were indicated by letters, such as 'SW' for a 'small woman' and 'W' for a woman of 'average' build. At this time altering ready-made clothes to suit the purchaser's figure and needs was the norm whether the alterations were offered as a service by the retailer or done at home. In the 1950s, following research by the British Standards Institution (BSI), a more accurate labelling system indicated by numbers (10, 12, 14, 16, 18, 20) and the letter 'S' for short and 'T' for tall, was introduced. This followed the North American numbering system.

Britain did not adopt America's half sizes nor their larger range of five figure types. American clothes, and half sizes, were popular and were sold in Britain. From the mid-1970s some companies began to introduce metric measurements as well as imperial measurements when measurements were used as a size indicator. However, it is important to remember that new systems overlapped with old ones and for a long time there was limited consensus on the form a label should take. An article published in the *Manchester Guardian* in 1954, 'One System for Clothing Labels' (19 May 1954, p.5) asserted that at the time of writing, when details of the new BSI system were announced, 'there are at present half a dozen competing sizing systems'. Referring to the BSI initiative, the same article commented, 'A similar attempt to rationalise the sizing labels for men's and boy's wear has met with no success'. Sizing and communicating size remain an issue today.

Fibre timeline: in the case of garments made from semi- and fully synthetic fibres, information gleaned from the look and feel of the material, and the presence of labels, can be supported by and checked against the date when the fibre became commercially available. However, it is important to be aware that the latter can differ from country to country, and even within a country. For example, in the USA nylon stockings were first released for sale to the public in 6 selected stores in Wilmington, Delaware in October 1939, a few months ahead of the countrywide launch in May 1940. In Britain domestically-manufactured stockings were not commercially available until 1947–48.



1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Acetate Rayon
Acrylic
Casein fibre
Chardonnet Silk
Cuprammonium rayon
Elastane
Lyocell
Modacrylic
Nylon 6
Nylon 6.6
Polychloroprene
Polyethelene
Polylactide PLA
Polypropylene
Polyester
PVC
Soybean fibre
Triacetate
Viscose Rayon
Key
In development, not in production
In limited production
In commercial production

4.4 Fibre identification

Fibre identification of semi and fully synthetic materials can be difficult. The fibre is often a blend, as discussed in section 2.6 Blended fibres, and the warp and the weft fibres may be different. Identification is important and full identification the ideal, but just noting the presence of likely semi and fully synthetic materials is helpful. Not only does it increase understanding of the garment, but it may also influence the conditions in which it should be kept and how it should be displayed. (For general care guidelines please see section 4.6 Caring for synthetic garments and for care requirements of specific fibres see section 3 Featured fibres.) The most important first step is to date the garment under investigation. See section 4.3 which includes a fibre timeline. This may help you narrow down the possible fibres.

Sight and touch: traditional materials are identified principally through a combination of sight and touch. The same methodology can be successfully used in the identification of synthetic materials. We strongly recommend collecting samples of identified materials of all kinds for comparison with unknown ones to develop a tactile understanding of them, so far as differences are perceptible. Clive Hallett and Amanda Johnson, *Fabric for Fashion: The Swatch Book*, (Amsterdam: Bis Publishers, 2022) provides such a resource by including 125 swatches of the most used varieties of natural and synthetic fabric.

Some materials have specific characteristics, they may be prone to pilling and or static; they may discolour with age or become sticky. Such identifying characteristics are included in the fibre descriptions in section 3 Featured fibres.

Fibre and care labels: individual countries, and political and economic groups such as the European Union, have different regulations governing fibre and care labels. The USA was the first country to introduce compulsory labelling of textiles with their fibre content in 1960, followed by mandatory care labels in 1972. The European Community introduced compulsory labelling of textile products with their fibre content in 1971 and this legislation was adopted by new member states as they joined. At the time of writing, wash care labels are not required by law in the UK or EU, but if an individual damages a garment by using incorrect cleaning methods, the manufacturer is liable for the cost of repair or replacement. Fibre labels however are mandatory. Labels of both types are found on garments which pre-date the legislation that made them obligatory or the producer liable for damage. They were added at the discretion of manufacturers. In the 1950s the labels were text based. Standardised wash code symbols have evolved since 1966. For a DATS guide to dating collections using standardised wash codes on garment labels, please see 7. Bibliography and other resources, Fibres (general): Identification aids.

Fibre labels can be confusing. In the case of semi-synthetic and synthetic garments, often the registered trade name, for example Celanese, Terylene or Acrilan, is listed on the label rather than the synthetic fibre type, in these cases cellulose acetate, polyester and acrylic. In addition to this, early labels often list only the fibre type of the main material. However, from the 1970s labels began to identify the material of the lining, usually without specifying which part of the garment is made from which material. (For examples of guides to current legislation regarding fibre labels in the USA, EU and UK please see section 8. Bibliography and other resources, General: Labelling regulations.)

Fibres under the microsope: The use of a light microscope is a good technical test in identifying textile fibres. Fibres can be examined under powerful magnification normally of a minimum x100 magnification to enable the characteristics of the fibres to be clearly viewed. Microscopes can be used not only for imaging but for measurement of physical and chemical properties by diffraction, spectroscopy and other specialised methods. For example, microscopes can be used in several different ways:

- Electron-magnetic radiation (light microscopes)
- Using electrons (scanning electron microscopes (SEM))
- By scanning microscopically sharp probe across surfaces (scanning probe microscopes (SPM)).

The use of light microscopes is a popular choice for identifying textile fibres because they can be accessible to collection care staff in studios and/or in storage areas. This technique is useful for identifying synthetic fibres in dress artefacts if sampled correctly. Fibres can be examined easily on glass slides with the use of a mounting medium with low refractive index, usually glycerol is used for this purpose. This preparation in mounting fibres helps to enhance the contrast of the image under powerful magnification, including the depth of field which can be adjusted on a microscope. Digital imagery with associated software can also aid the clarity of images.

Polarised light microscopy (PLM) is another useful technique to identify synthetic fibres. Using a microscope equipped with two polarised filters which converts the light into a plane of polarised light that passes through the specimen (the fibre). When the light passes through the filters a fringe patterning is transmitted though the specimen. Birefringent[1] fibres like synthetic fibres, when placed between the filters become visible as bright objects on a black background, as well as looking very attractive with rainbow colours, can provide additional clues to identification (see Figure 1).

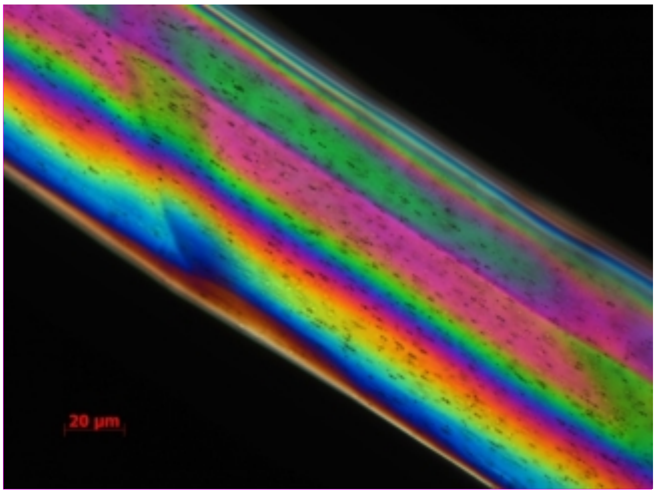


Figure 1. Nylon fibre under polarised light microscopy (PLM) showing light transmittance through polarised filters. (https://cameo.mfa.org/wiki/Nylon_Filament)

[1] Optical property of a material having a refractive index that depends on the polarisation and propagation direction of light.

These are fibres that are mounted lengthwise for examination. Polyester and nylon are smooth, cylindrical rod-like fibres and nylon fibres are often transparent and look like glass rods under a microscope. The longitudinal view of synthetic fibres usually corresponds to what the cross-sectional shape is like. For example, the most common cross-sectional fibre shape, round, will have a smooth rod-like longitudinal view. A trilobal cross-sectional view will produce a longitudinal fibre shape with ridges, lines, or striations running down the fibre lengths.

Cross sectional view: When fibres are produced by the melt spinning method, changing the spinneret hole shapes results in variations on the cross-sectional shape of the fibres (see Figure 2). Nylon and polyester are often round, trilobal to triskelion (Y-shaped). Cross-sectional shapes can often give an insight into the properties and qualities of the textile i.e., drape, feel, softness and lustre.

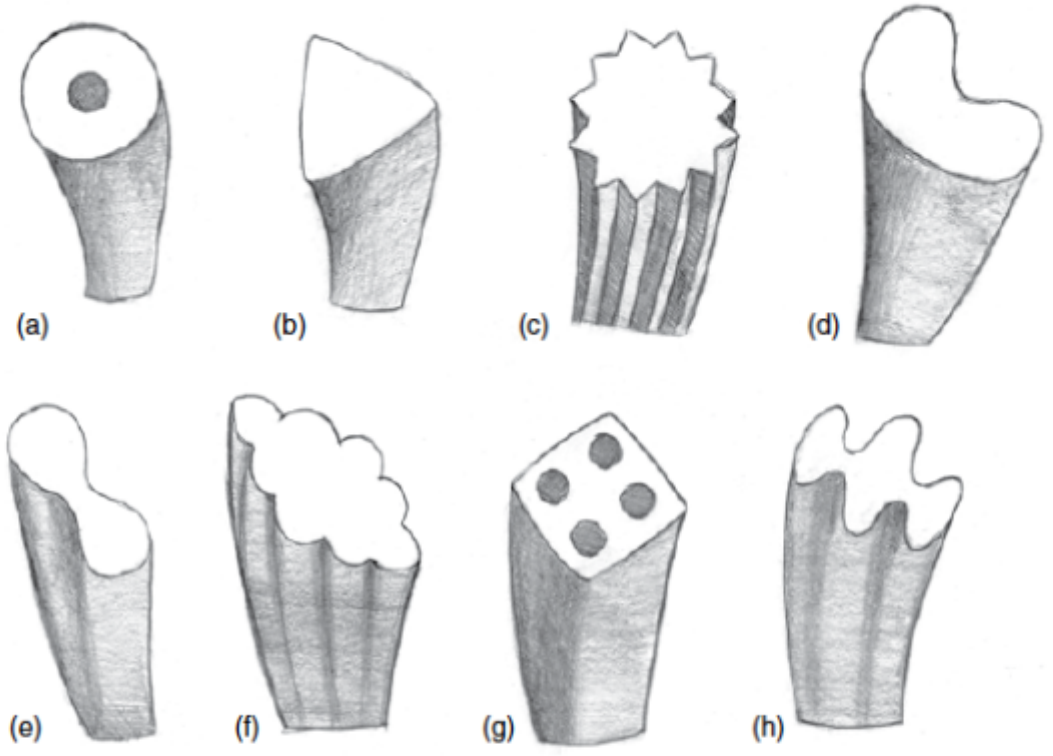


Figure 2. Cross-sectional view of variety of shapes in manufactured fibres. a) Hollow round, b) triangular, c) serrated, d) kidney bean, e) dog bone, f) wavy flat, g) square with voids, and h) hexachannel. (Markova, I., 2019. *Textile Fiber Microscopy: a Practical Approach*. New Jersey: John Wiley and Sons, p.125.)

Delustrants: Synthetic fibres are normally bright and a delustrant is used to tone down the brightness. Under the microscope, the delustrant can be seen as a speckled fibre surface, referred to as delustrant granules (see Figure 3).

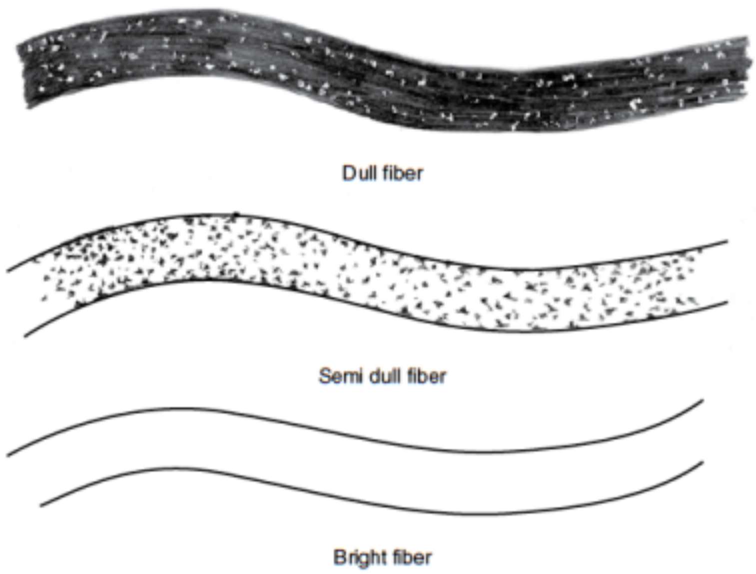


Figure 3. Types of fibre delustering. (Markova, I., 2019. *Textile Fiber Microscopy: a Practical Approach*. New Jersey: John Wiley and Sons, p.127.)

The microscopic images depicted below are created using a mix of SEM and light microscopy. They show some of the main synthetic fibre types to enable collection care users to become familiar with their characteristics under magnification. They include both light and polarised light microscopy techniques to indicate the different views that can be achieved in identifying synthetic fibres.

The images below are from a variety of sources and primarily used here as visual aids for users to gain an understanding of the characteristics of synthetic fibres whilst working with dress archives. Magnification of synthetic fibres can be found from a variety of sources and can slightly vary from one to another. Several cross sections are shown of the same fibre type. This is to demonstrate the comparable characteristics when identifying synthetic fibres.

Polyester

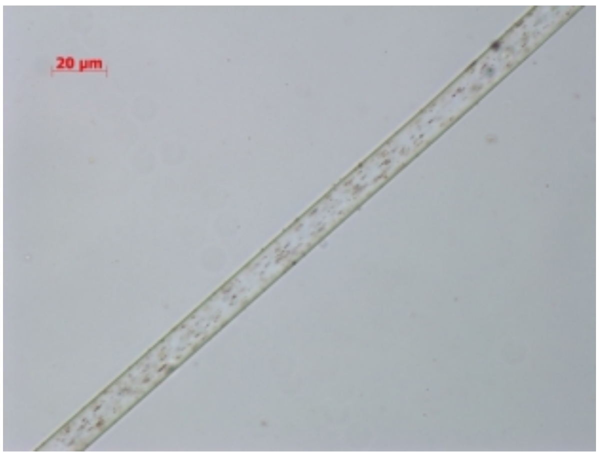


Figure 4. Light microscope x400 MAG. (https://cameo.mfa.org/wiki/Category:FRIL:_Polyester)

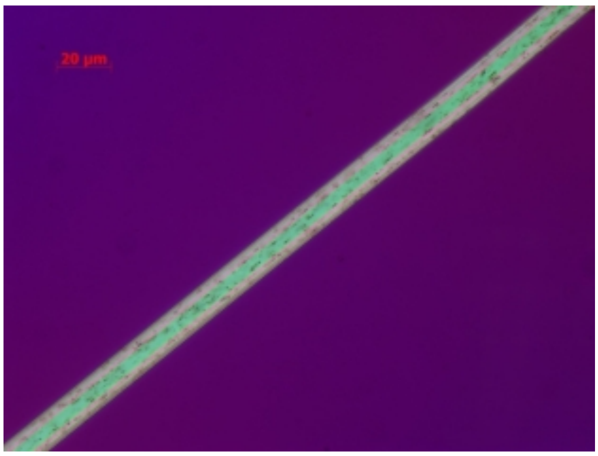


Figure 5. Polarised light microscope x400 MAG.

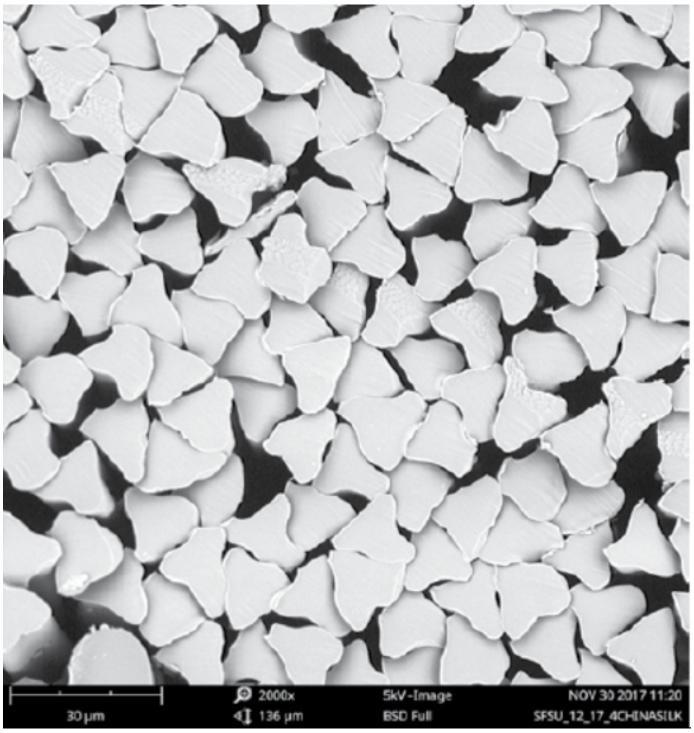


Figure 6. Trilobal shape of polyester fibres x3000 MAG. (Markova, I., 2019. *Textile Fiber Microscopy: a Practical Approach*. New Jersey: John Wiley and Sons, p.130.)

Nylon

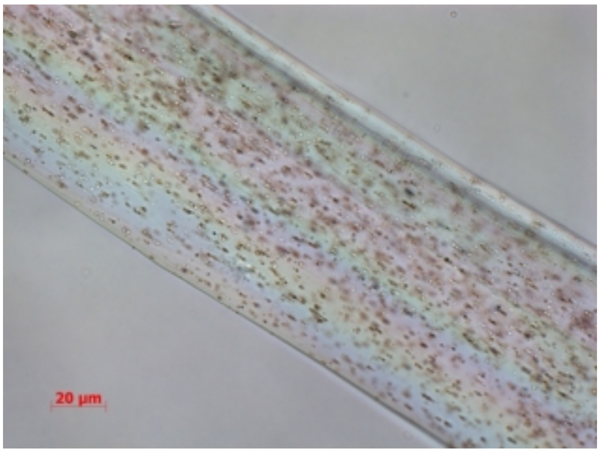


Figure 7. Light microscope x400 MAG. (https://cameo.mfa.org/wiki/Nylon_Filament)

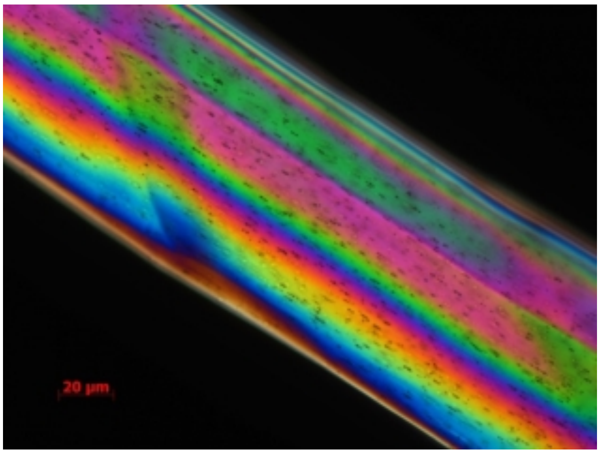


Figure 8. Polarised light microscope x400 MAG.

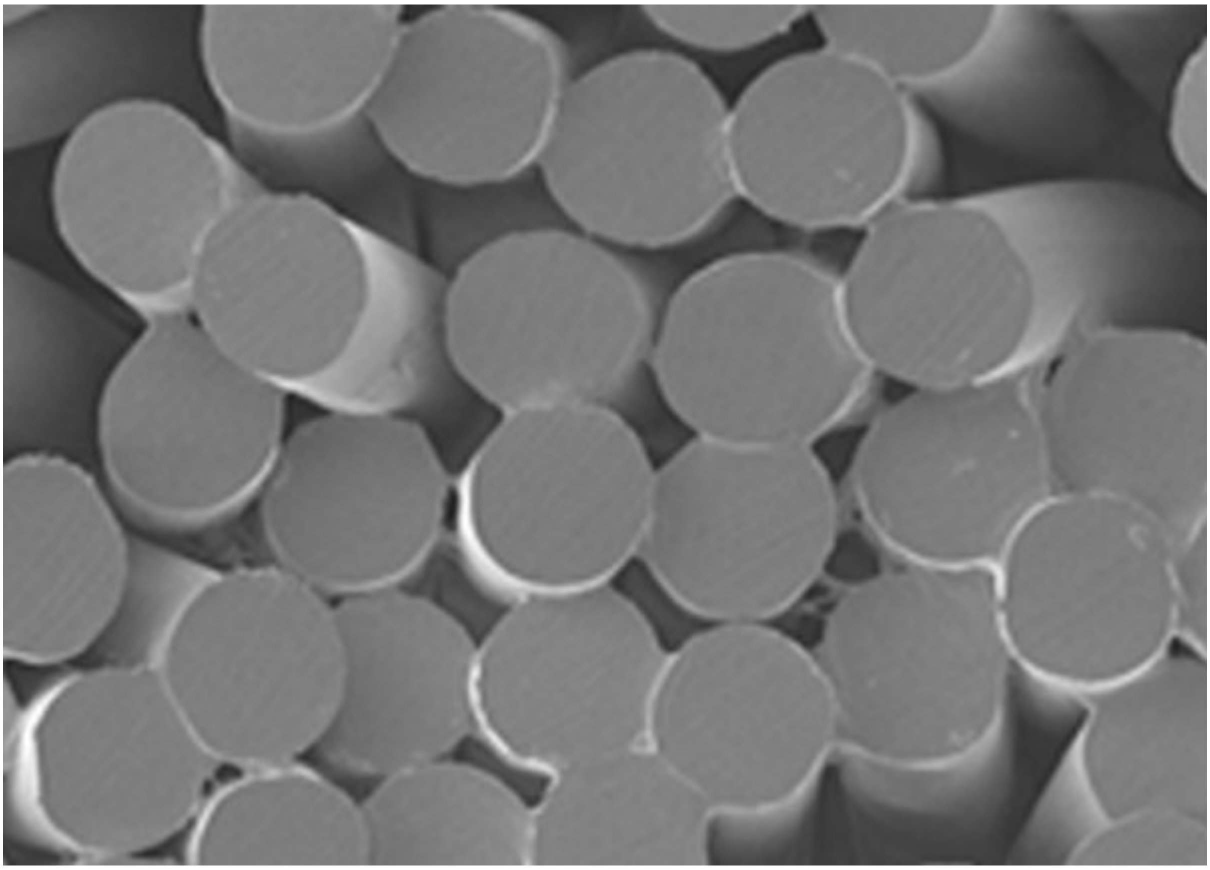


Figure 9. SEM Image of nylon fibres cross-section. (https://www.btraindia.com/sem.html)

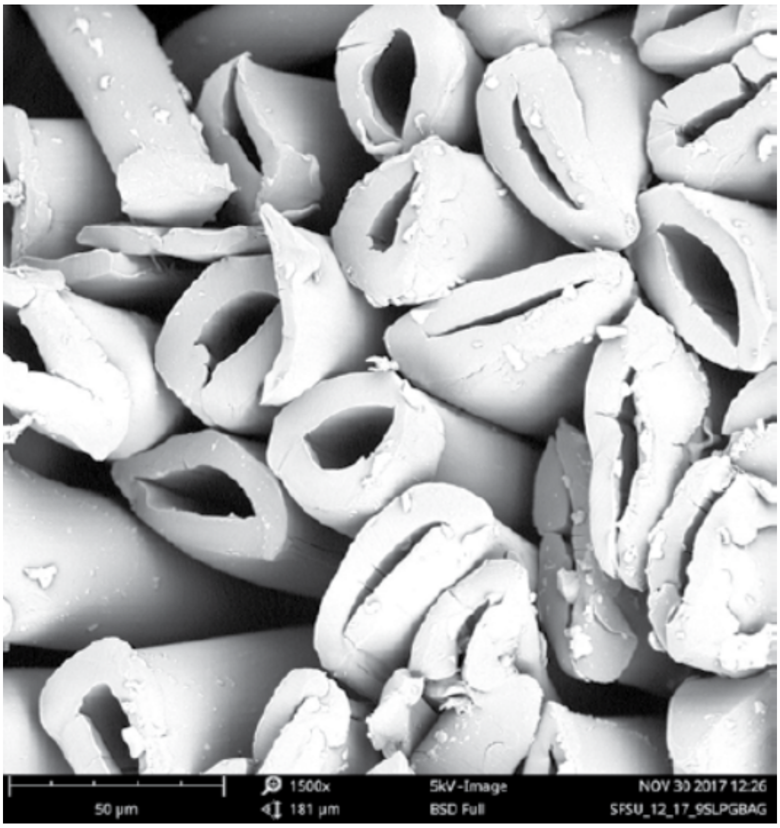


Figure 10. Hollow nylon fibres cross-section x1500 MAG. (Markova, I., 2019. *Textile Fiber Microscopy: a Practical Approach*. New Jersey: John Wiley and Sons, p.132.)

Acrylic

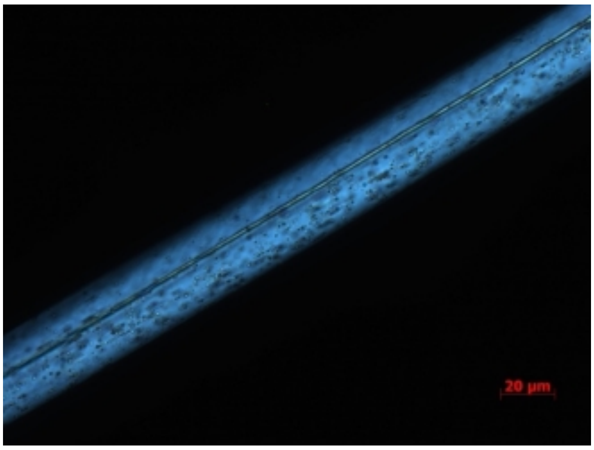


Figure 11. Light microscope x400 MAG. (https://cameo.mfa.org/wiki/Category:FRIL:_Acrylic)

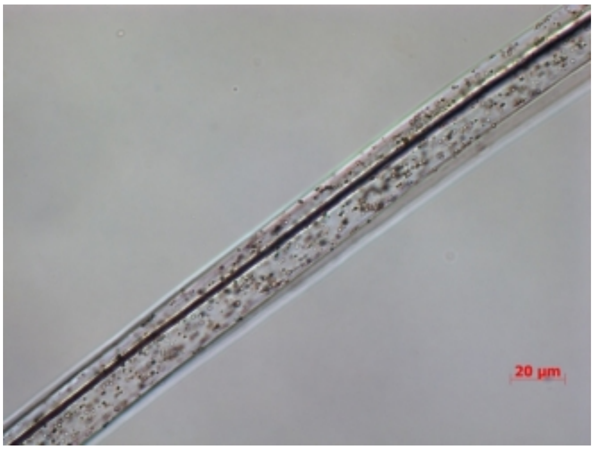


Figure 12. Polarised light microscope x400 MAG.

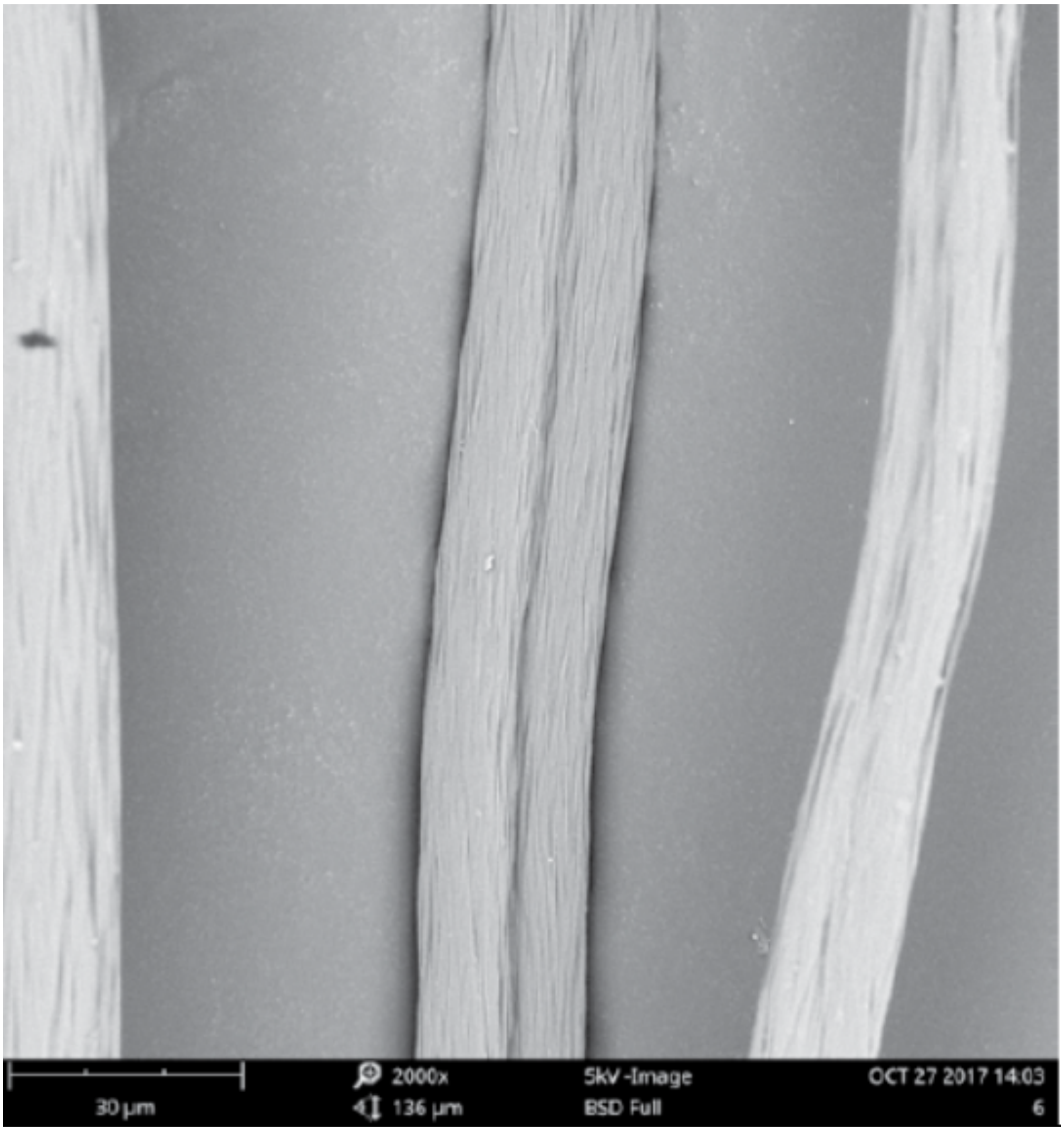


Figure 13. Longitudinal view of acrylic fibres (uses as artificial fur) x2000 MAG. (Markova, I., 2019. *Textile Fiber Microscopy: a Practical Approach*. New Jersey: John Wiley and Sons, p.132.)

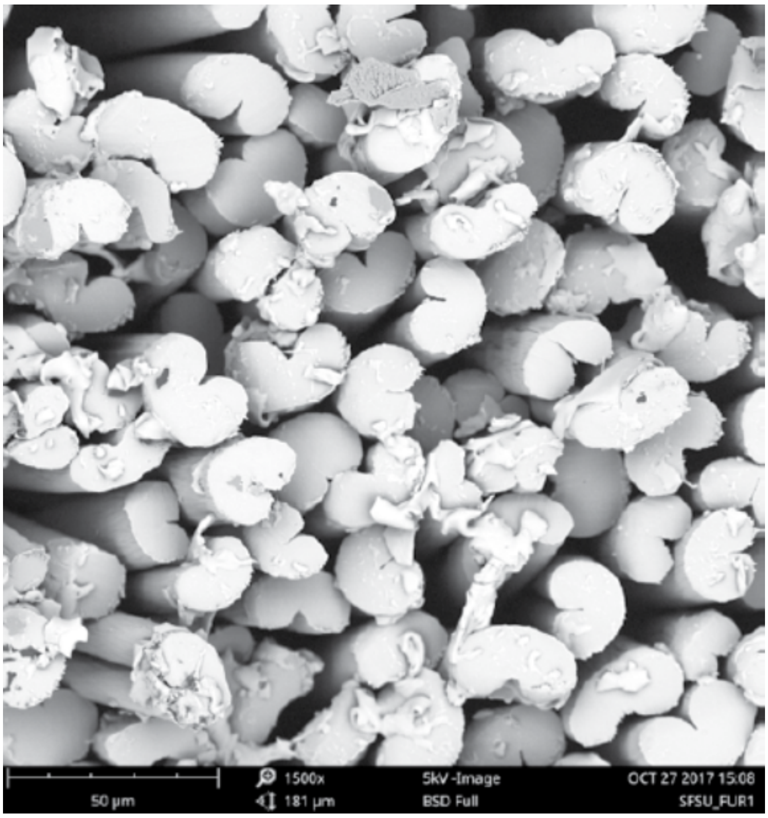


Figure 14. Kidney bean cross-section acrylic fibres (uses as artificial fur) x1500 MAG. (Markova, I., 2019. *Textile Fiber Microscopy: a Practical Approach*. New Jersey: John Wiley and Sons, p.132.)

Figure 15. Dog bone cross-section acrylic blanket fibres x2000 MAG. (Markova, I., 2019. *Textile Fiber Microscopy: a Practical Approach*. New Jersey: John Wiley and Sons, p.132.)

Rayon

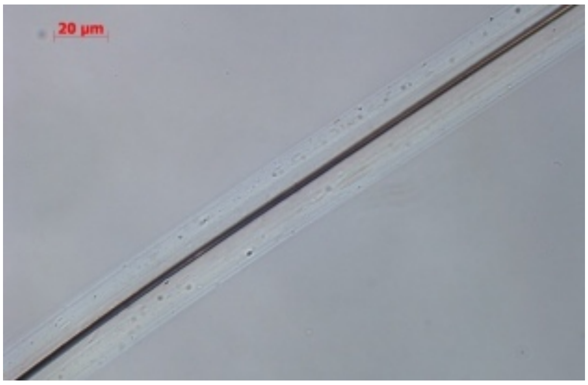


Figure 16. Light microscope x400 MAG. (https://cameo.mfa.org/wiki/Category:FRIL:_Rayon)

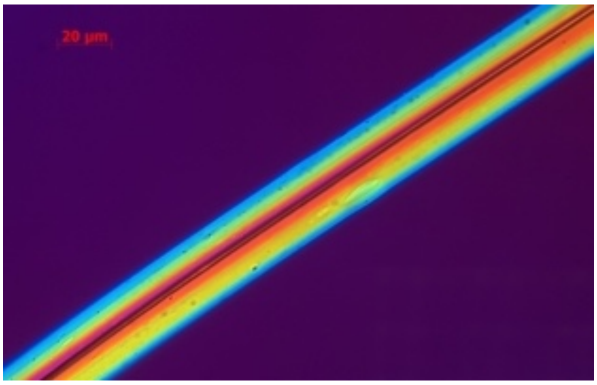


Figure 17. Polarised light microscope x400 MAG.

Cuprammonium Rayon

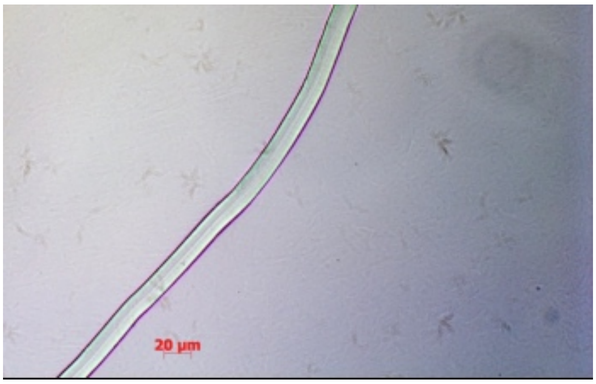


Figure 18. Light microscope x200 MAG. (https://cameo.mfa.org/wiki/Cuprammonium_Rayon,_OSU)

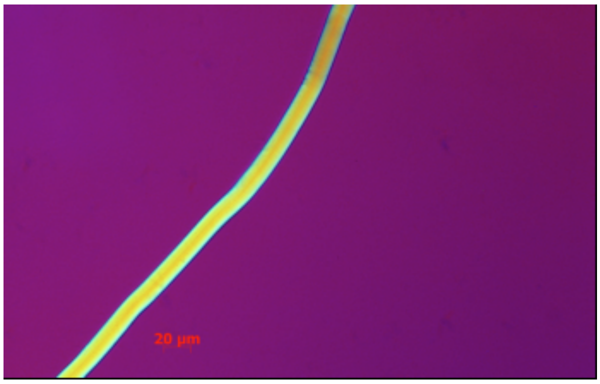


Figure 19. Polarised light microscope x200 MAG.

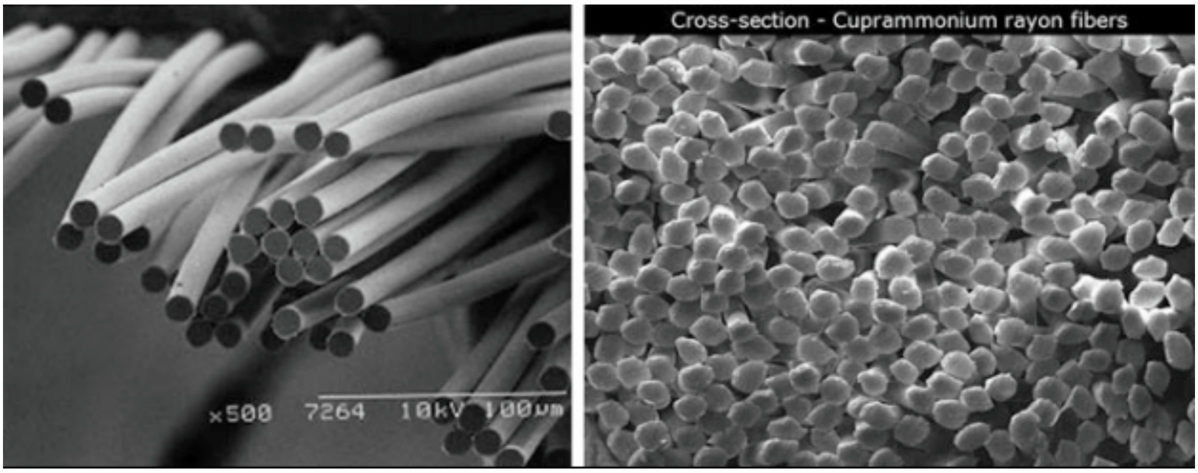


Figure 20. SEM Cross-sectional views x500 MAG. (Rana, Sohel, Subramani Pichandi, Shama Parveen and Raul Fangueiro, 2014. Regenerated cellulosic fibers and their implications on sustainability. In *Roadmap to Sustainable Textiles and Clothing: Eco-Friendly Raw Materials, Technologies, and Processing Methods*, pp.239–276. https://doi.org/10.1007/978-981-287-065-0_8.)

Acetate

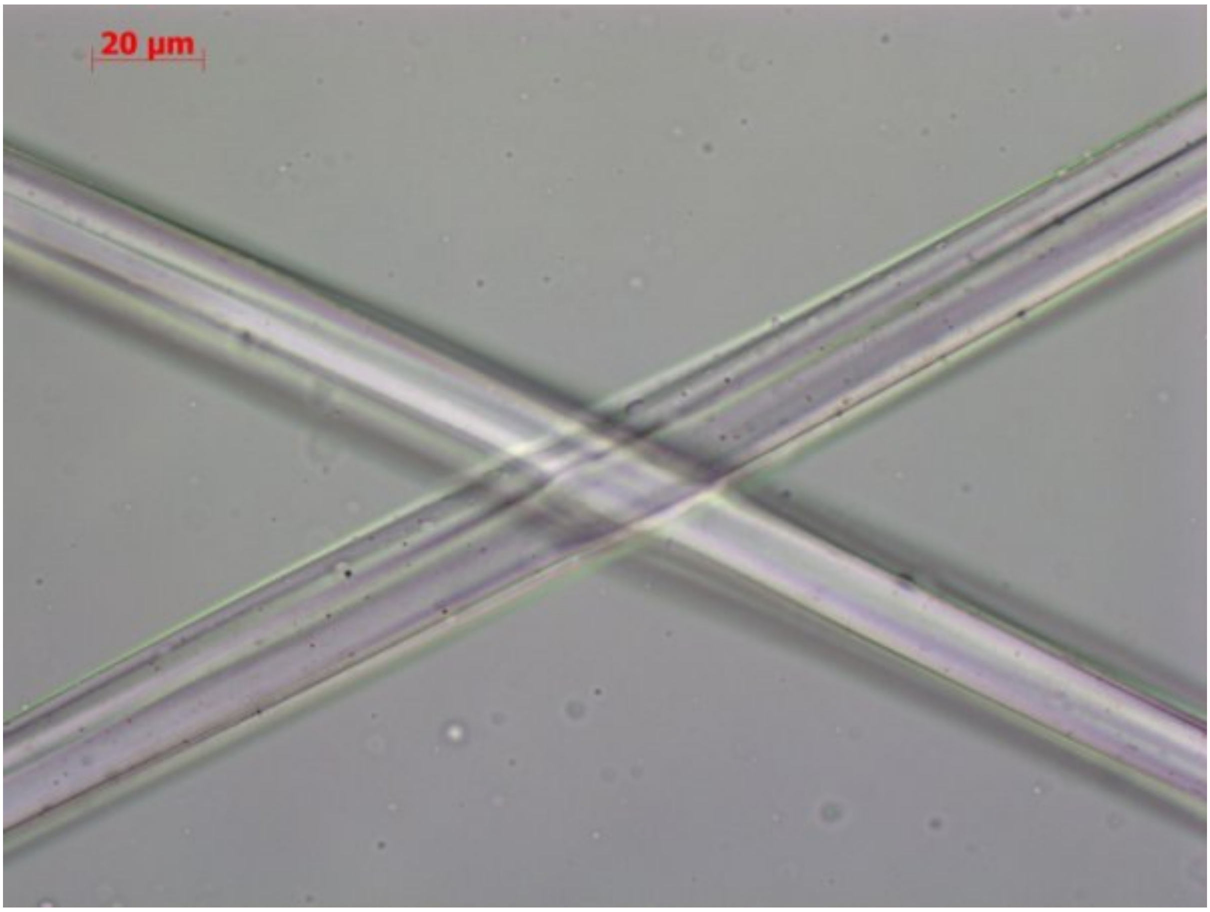


Figure 21. Acetate fibre. Light microscope x400 MAG. (https://cameo.mfa.org/wiki/Category: FRIL:_Acetate)

Viscose

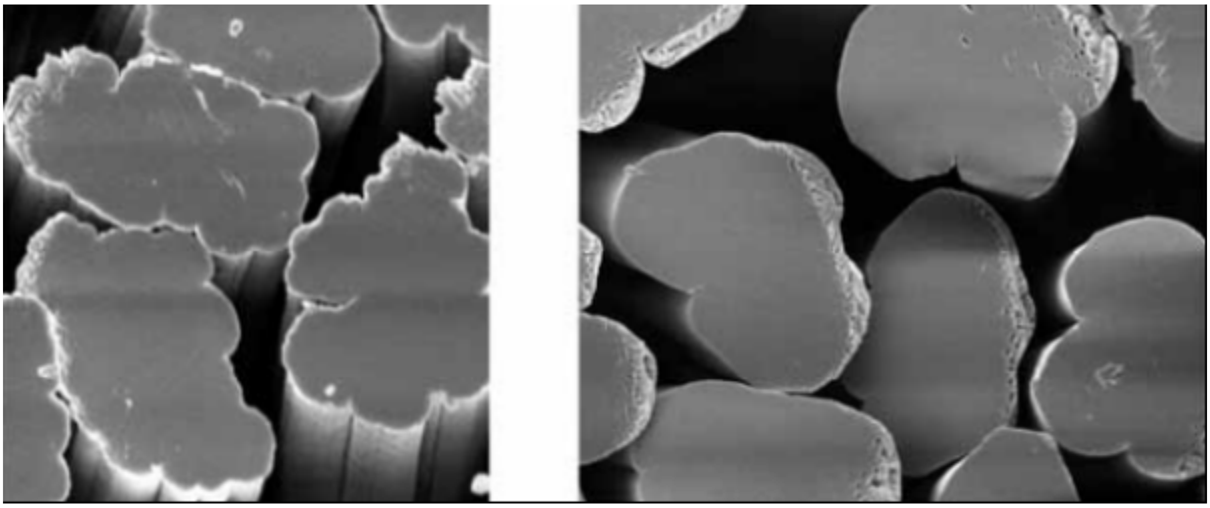


Figure 22. Cross-sectional SEM image of standard viscose (left) and modal viscose (right). (Röder, T. et al. 2013. *Man-Made Cellulose Fibres - a Comparison Based on Morphology and Mechanical Properties*, p.9.)

Regenerated viscose

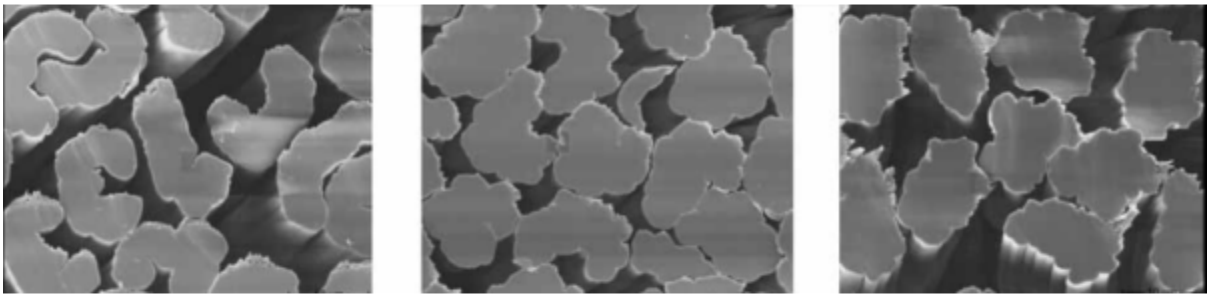


Figure 23. Cross-sectional SEM image of regenerated viscose fibres using increasing amounts of poly(lactic acid) from left to right. (Röder, T. et al. 2013. *Man-Made Cellulose Fibres - a Comparison Based on Morphology and Mechanical Properties*, p.9)

Lyocell

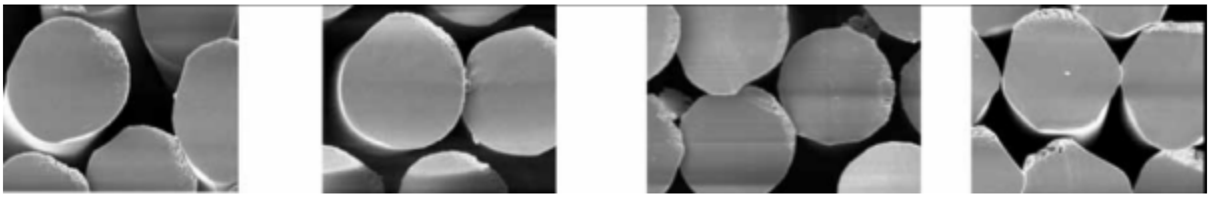
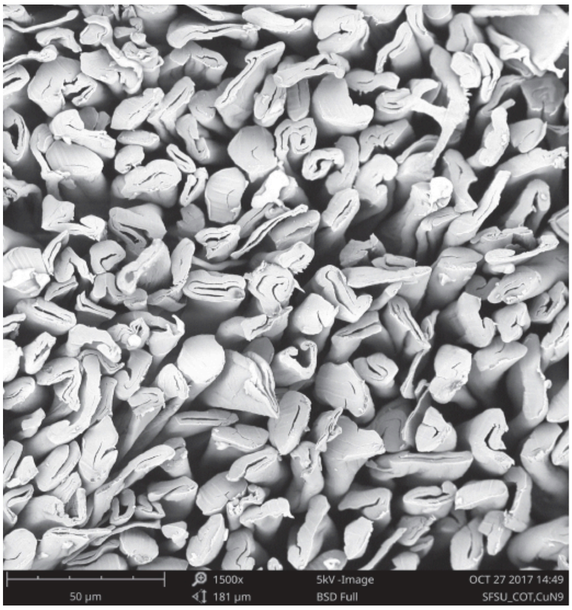
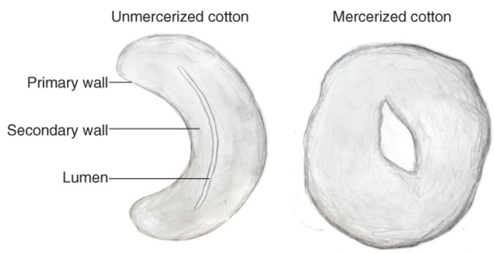


Figure 24. Cross-sectional SEM image of Lyocell fibres: TENCEL (left); EMIM-CI; BMIM+CL; BMIM-Ac (right) (Röder, T. et al. 2013. *Man-Made Cellulose Fibres - a Comparison Based on Morphology and Mechanical Properties*, p.10.)

Traditional fibres: When identifying synthetic fibres it is important to be able to rule out traditional (or what are sometime called natural) fibres. It can also help when looking at blended fibres discussed at 2.6. To that end, we include magnified cross sections of some traditional fibres for comparison with synthetic fibres.

Cotton





Figures 25 & 26. Cross-section of cotton fibres with a variety of wall thickness showing mature fibres with thick cell wall and a small lumen and immature fibres U shape cross-section with a thin cell wall (1500x) (Markova 2019: 4) with depiction of physical structure of cotton fibres (Markova 2019: 3).

Wool

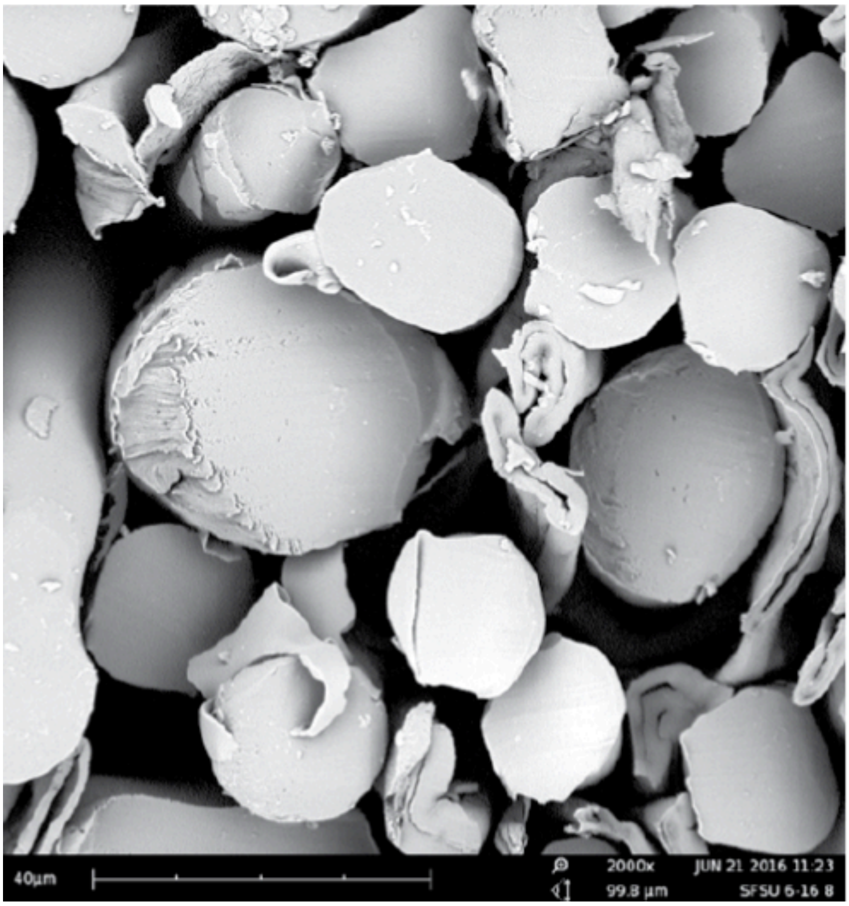
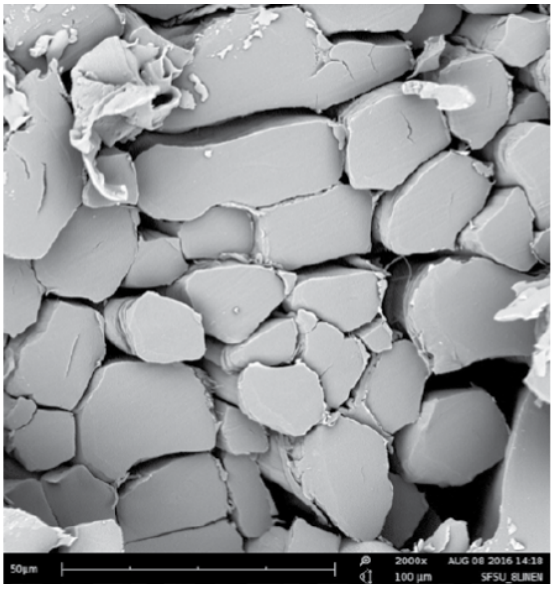
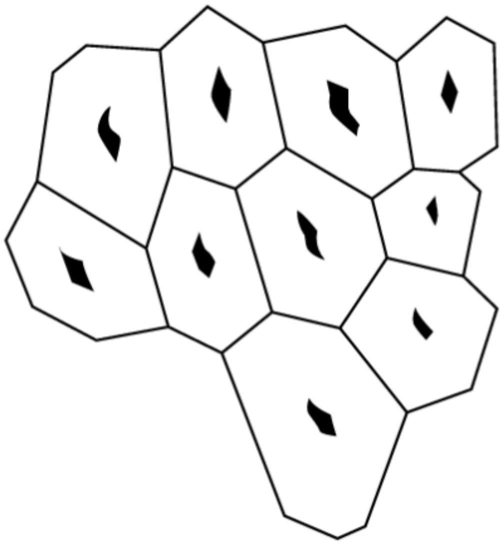


Figure 27. Cross-section view of wool fibres showing circular fibre shape (2000x) (some cotton fibres are mixed in) (Markova 2019: 40).

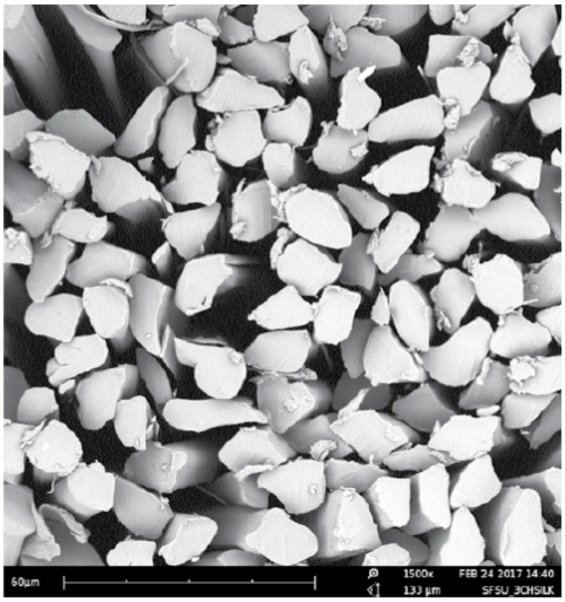
Linen

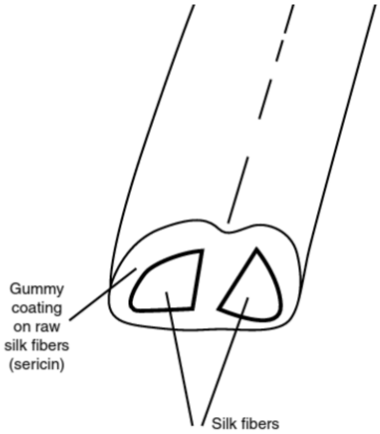




Figures 28 & 29. Cross-section view of linen individual fibres (ultimates) and fibres bundles. Individual linen fibres showing polygonal fibre shape (2000x) with depiction of fibre bundles composed of individual fibres of polygonal shape. Bast fibres come in fibre bundles which can be separated I to fibre ultimates (Markova 2019: 15).

Silk





Figures 30 & 31. Cross-sectional shape of cultivated silk (China silk) depicting triangular cross-section. Triangular cross-section becomes very important in cultivated silk. It adds lustre to silk fabrics (1500x) with depiction of the elliptical shape – two fibres (two strands) with sericin holding the triangular twin fibroin or strands together (Markova 2019: 70).

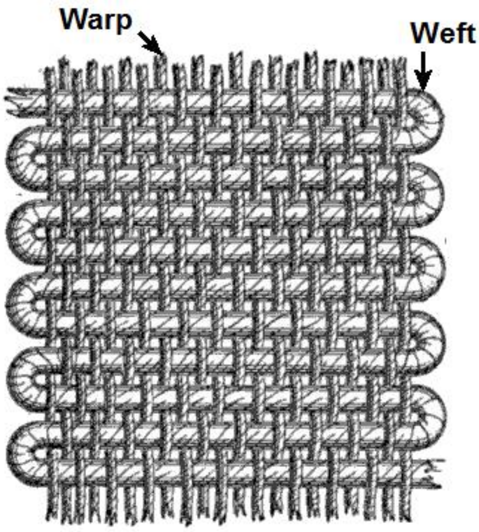
FTIR spectroscopy: we have found the most practically reliable way of identifying fibres is by attenuated total reflectance (ATR) Fourier transform infrared (FTIR) spectroscopy. It excels at distinguishing between the fully synthetic polymeric fibres but (where possible) requires a lot more experience to distinguish between the semi-synthetics, which are based on a limited number of starting materials with the difference often relating to how they are processed.

In this technique, the fibres are subjected to infrared radiation. Some of the radiation is absorbed and some of it is passed through (transmitted). The resulting spectrum (graph) represents the molecular absorption and transmission, creating a molecular fingerprint of the sample fibre. The spectra of the fibres found in the documented garments are provided in the relevant entries in section 3 Featured fibres and materials.

The FTIR procedure can be run either on selected areas of the garment or sample fibres taken from it. The process requires the application of considerable pressure which means that involving the whole garment can lead to damage to the selected areas. Furthermore, this approach does not allow the separation of the warp and weft fibres. We chose fibre sampling as less damaging and more informative. However, the selection of fibres to sample is crucial. Any analysis can only tell you about the samples and thus the part of the garment from which they were taken. (For guidance on taking samples, please see section 4.2.)

A related, completely non-invasive, recently trialled procedure, which also requires taking the object to the spectroscope, is reflectance FTIR. (For more information, please see 7. Bibliography and other resources, Fibres (general): Analysis.)

4.5 Synthetic textile sampling guidelines



What to sample: in a textile sample warp and weft refer to the direction of the woven threads. The warp is the lengthwise threads on the fabric loom. The weft are the horizontal threads. They are threaded over and under the warp threads. The two threads are not always spun from the same material, so it is important to take a fibre sample of both warp and weft for identification.

Tools and equipment required:

- Small sharp pointed scissors
- Finely pointed tweezers
- Sharp scalpel with curved surgical blade
- Microscope slides and cover slips
- Small clear resealable polythene zipper plastic bags and white or coloured paper
- Dark coloured cutting mat or other dark cutting surface.

Sampling (for FTIR and microscopy): fibres can be identified from very small samples. Typically, ~0.5cm is clipped from an exposed yarn end in good condition in an inconspicuous area (e.g., selvedge or seam). Sometimes a longer sample may be taken for ease of manipulation. Both warp and weft yarns should be sampled because some fabrics are made of one fibre type in the warp and another in the weft. Care should be taken that samples are taken from the fabric under consideration and not sewing threads. It is important to document the sample location(s) in the written records, accompanied by a photograph. Once taken, fibre samples should be placed in the fold of a white or coloured paper that has been labelled (this makes it easy to see and manipulate them) and placed in a small resealable polythene zipper plastic bag. The outside of the bag should also be labelled.

When sampling laminate fabrics a thin cross-section of all the layers is taken from the selvedge of the material using a curved surgical blade. The curved blade assists with control and enables one to take samples of the top, bottom and any middling layers to identity them in the correct order.

The sample is then mounted on a glass slide as if mounting a fibre and the top and bottom is noted. These samples are then examined under a microscope enabling top, bottom and any middle layers to be identified.

4.6 Caring for synthetic garments

General conservation and collection care advice applies also to those made of semi- and fully synthetic fibres and should be followed. Such advice can be found at: https://collectionstrust.org.uk/wp-content/uploads/2017/02/Museums-Galleries-Commission-An-Illustrated-Guide-to-the-Care-of-Costume-and-Textile-Collections-2000.pdf.

For most synthetic garments, dissociation and loss of material information poses the greatest risk for identifying future preservation needs. In 2022 a relatively small number of synthetic textiles show signs of degradation and research to understand why is starting. So, at this time, early signs of change should be documented, and conservation advice sought as needed. It is recommended that collections containing synthetic and semi-synthetic fibres and plastics are examined at six-monthly intervals. If staffing levels and work programmes make this ideal impossible, regular checks at longer intervals can still detect problems developing. Vigilance is also needed for synthetic plastic decorative elements like buttons, and stiffening interfacings in belts, collars and cuffs that are particularly vulnerable to degradation. Appropriate care advice is available in the PSSN 'A Curator's Guide' (see section 8.1 Bibliography and other resources, General: Preservation advice).

Environmental conditions: the temperature at which some synthetic garments are stored and displayed has more impact on their long-term preservation than is the case with natural materials. As a rule, the storage for all semi- and fully synthetic garments should be kept below 20°C. Relative humidity levels are also more crucial and, again as a general guide, should not drop below 40%. This is especially important for cellulose triacetate, nylon, polyester, and acrylic fibres which are prone to an increase in static charge when air humidity is low and has little air moisture. At the other end of the air-moisture scale, rayons and protein-based fibres readily attract water, making them vulnerable to mould in damp conditions when relative humidity exceeds 70%.

Storage: store textiles in the dark but also ensure that light levels in storage areas are sufficient so that textiles can be examined without strain when necessary. Storage space in museums can be cramped. While some garments will be robust enough to be hung in wardrobes, it is very important to combine vertical storage with horizontal storage such as acid-free boxes for textiles, small items of clothing and garments that are too fragile to be supported from their shoulders or waist, or might become distorted if hung. Bias cut garments and garments made from jersey and other stretch fabrics should always be stored flat.

Objects showing signs of degradation should ideally be stored in the configuration they would be displayed, for instance on a display mount or padded board. Otherwise, like garments prone to stretching, they should be stored flat.

Conservation-grade covers should be used to protect against the static attraction of dust to cellulose triacetate, nylon, polyester and acrylic fibres. Care should also be taken to minimise static build from textiles rubbing together in storage and when handled. This applies to used and unused static-prone garments because anti-static treatments readily wash off after a few cycles of domestic laundering and it appears that their protective properties reduce with ageing.

Handling and display: as is the case with garments made of traditional materials, well-fitting, powder free nitrile gloves should be worn for routine handling. If you want to experience the feel of the fabric it is important to wash and dry your hands thoroughly before doing so and then to wash them again once you have finished. Gloves should always be worn when handling materials which incorporate or are decorated with metal threads as oils from the skin can cause tarnishing. There are recycling schemes for disposing used nitrile gloves.

Synthetic fibres, compared with natural fibres, have increased potential for stretching under load, especially nylon and synthetic rubber. Elastanes can stiffen and become misshapen. Supported handling and careful mounting for display is very important, paying careful attention to minimising flex at seams, areas weighted with metal zips, beads and suchlike, and bonded fabrics and coated fibres where layers can delaminate.

Maintain light levels where textiles are displayed at a maximum of 50 lux with UV levels as low as possible, but preferably below 30 µwatts/lumen (a total UV exposure of 1500 $\mu W/m^2$).

Examples of degradation and vulnerability: observation suggests that many semi-synthetic and synthetic fibres are relatively stable. However, some aged synthetic finishing and coating materials on garments in museum and archive environments are showing signs of chemical degradation and irreversible changes. Migration of plasticiser to the surface seen in PVC garments and some pleather (polyurethane imitation leather) is the main form of degradation. Removal of this sticky material from the surface is only a temporary solution as more of the plasticiser will migrate eventually leading to brittleness. These types of materials are best stored wrapped in silicon release paper to avoid adhesion and enclosed in either acid-free costume boxes or encased in calico slings/covers in a cool environment.

Some semi-synthetics and fully synthetic materials attract dust which can accumulate on the surface of the textile. Gentle and regular brushing with soft conservation grade brushes can help reduce the impact of dust damaging garments on display, particularly those on open display where garments are displayed without vitrines.

Wear and tear can affect the condition of some semi-synthetics and synthetic garments. A typical example is the effect of perspiration from previous wearers. This can often lead to synthetic fibres staining and/or rotting in local areas, for example, the under arm and torso.

Like wool, some synthetic fabrics, for example acrylic, cuprammonium, nylon and polyester are prone to pilling. Home gadgets to comb or shave off pilling have been available for decades and may have been used by previous owners, so well-worn garments with and without pilling are best displayed unmounted in case their structure has been weakened. Removing attached pills, or even loose ones, from historical garments is not recommended because of material and information loss.

Viscose rayon dating from before about 1956 has poor wet strength. These garments need particularly careful handling if they undergo water-based cleaning treatments and will require gentle reshaping while drying.

5. Documented garment examplars

Arranged in the date order of the garments' manufacture.

1920s

1.

Man's Aertex drawers (underpants) of woven viscose rayon and cotton

See section 3 Viscose rayon

Object number

Westminster Menswear Archive: WMA.2019.185

Designer/Maker/Manufacturer/Retailer

Cellular Clothing Co. Ltd. for its Aertex brand

Production country of the garment and components

England

Production date

circa 1910–20

Description

Pair of pale cream drawers made of viscose rayon and cotton with legs to mid-thigh. They have a high waist with woven cotton reinforcing the inside fly. At the centre back of the waist are four eyelet holes to allow lacing for fitting. The front fly is open with a two button and buttonhole fastening at the centre front waist (buttons missing).

Inside the front right waist is the maker's label for Aertex with the name in black lettering inside an oval in red.

They have been altered by threading a length of white elastic through the waist creating two holes at the centre back inside waist and two at the front (removed).

Context

The Cellular Clothing Co. Ltd. was established by mill owner Leslie Haslam in 1888 to manufacture 'Aertex' cotton woven cloth in Bolton, Lancashire. Aertex was registered as a trademark in 1895. In 1920 the company was acquired by the Amalgamated Cotton Mills Trust and then in 2001 it was bought by Aertex Ltd. The viscose rayon is used as an artificial silk.

Labels/Inscriptions

Label: THE CELLULAR CLOTHING COY LTD / AERTEX / 38 / LONDON / MADE IN ENGLAND / ARTIFICIAL SILK / & COTTON.

Methods

Fibre manufacture:	Farmed (cotton); extruded (viscose rayon)
Yarn manufacture:	Spun
Fabric construction:	Woven
Garment Construction:	Stitched

Material

Viscose rayon (main material); cotton (facing)

Measurements

Length: 55cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2019-185

2.

Jacket of knitted viscose rayon

See section 3 Viscose rayon

Object number

V&A: T.309-1965

Designer/Maker/Manufacturer/Retailer

Unknown

Production country of the garment and components

Britain

Production date

1920–25

Description

Jacket of machine-knitted viscose rayon, printed with a design in green, yellow and lilac inspired by Ancient Egypt. Knee-length and straight cut with a band collar falling open to suggest revers. Fastened at the waist with a silvered metal clasp on which is an impressed decoration of roses. Long sleeves with turned-back cuffs showing the unprinted inside of the jacket.

Context

Here viscose rayon is used as an alternative to silk.

Labels/Inscriptions

None.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Filament, twisted
Fabric construction:	Knitted
Garment construction:	Stitched

Material

100% viscose rayon

Measurements

Length: 25.5cm

Source

Bequeathed by Estella Canziani

More information on this object

https://collections.vam.ac.uk/item/O357449/jacket-unknown/

3.

Berkshire stockings of knitted Bemberg™ cuprammonium rayon

See section 3 Cuprammonium rayon

Object number

MoDiP: AIBDC: 007079

Designer/Maker/Manufacturer/Retailer

Berkshire (manufacturer)

Production country of the garment and components

USA

Production date

1924–29

Description

A pair of women's fully-fashioned off-white stockings with reinforced foot and toe, seamed along the side of the foot, the heel, and the back of the leg.

Context

Berkshire pioneered the use of rayon instead of silk in the production of women's fully-fashioned hosiery in 1924 and the word Bemberg was the trademark of this durable high quality synthetic yarn.

Labels/Inscriptions

Printed on one toe: Berkshire Stockings logo.

Printed on the heel of the same stocking: Berkshire Bemberg.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Filament, twisted
Fabric construction:	Knitted
Garment Construction:	Stitched

Material

Cuprammonium rayon (Trade name: Bemberg)

Measurements

Length: 92cm

Source

Purchase

More information on this object

https://www.modip.ac.uk/artefact/aibdc-

1930s

4.

Charles James cape of woven cuprammonium rayon and silk

See section 3 Cuprammonium rayon


Object number

V&A: T.1-1977

Designer/Maker/Manufacturer/Retailer

Charles James (designer); Colcombet, France (possibly, fabric manufacturer)

Production country of the garment and components

New York, USA

Production date

1936

Description

A long, flared, unlined evening cape made of multiple panels of satin in 5 colours, spanning from the collar of the cape to the 7-metre-wide hem. The pale yellow, gold, dark grey and pink panels are all 100% silk. The pale grey panels are of cuprammonium rayon.

Context

When examined closely, the DATS PSSN group found it very difficult to establish a visible or tactile difference between the silk and the cuprammonium panels. Cuprammonium absorbs dye well and it may have been chosen here for the delicate pale grey shade that could be achieved. The material used in this cape by Charles James (1906–78) was reportedly leftover millinery ribbon made in the early twentieth century by French manufacturer Colcombet.

Labels/Inscriptions

None

Methods

Fibre manufacture: Extruded

Yarn manufacture: Filament, twisted

Fabric construction: Woven

Garment Construction: Stitched

Material

Cuprammonium rayon (light grey); silk (yellow, gold, pink, dark grey)

Measurements

Length: approx. 150cm

Source

Given by Cecil Beaton

More information on this object

https://collections.vam.ac.uk/item/O359921/cape-charles-james/

5.

Dress of hand-painted woven viscose rayon and acetate rayon

See section 3 Acetate rayon; Viscose rayon

Object number

V&A: T.46:1, 2-2017

Designer/Maker/Manufacturer/Retailer

Unknown, probably custom made for client Leah Barnett Ross (née Lyons, 1915–69)

Production country of the garment and components

Britain (probably)

Production date

1937

Description

Full length dress in black satin weave viscose and acetate rayon, hand-painted with a repeating pattern of red, green, white and gold skiers and snow-laden pine trees, probably stencilled to ensure the repeat. The dress cut in a slim line, with a straight skirt slit up the centre front to mid-calf, and a fan-pleated godet in the centre back. The bodice raglan cut, short sleeved, with a high round neckline, the collar and cuffs of grey-gold fur. A short peplum at the waist gives a jacket effect. The bodice fastens centre front with four bound buttonholes, each of which holds two miniature plastic buttons (probably urea formaldehyde) in the form of skis, and the opening below the waist is fastened with press studs. Black belt in soft suede leather, faced with leather and fastening with two white plastic skis threaded through metal hoops and attached by a fine silver chain to the belt.

Context

This dress was owned and worn by Leah Barnett Ross (née Lyons, 1915–69). She was painted wearing the dress by the society portrait painter James Penniston Barraclough (1891–1942). The painting was commissioned by her husband, Basil Ross, whom she married in 1935. The painting hung in the hallway of the family home.

Labels/Inscriptions

Tape sewn inside the lower hem of the skirt: Indoor Sports [possibly referring to the designers' name for the dress].

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Twisted
Fabric construction:	Woven
Garment Construction:	Stitched

Material

Warp of acetate rayon, weft of viscose rayon

Measurements

Length: 145cm, waist circumference: 66cm

Source

Given by Joanna & Philip Ross in memory of Leah Barnett Ross (née Lyons)

More information on this object

https://collections.vam.ac.uk/item/O1376931/indoor-sports-dress-unknown/

6.

Teddy slip of woven Celanese acetate rayon

See section 3 Acetate rayon

Object number

MoDiP: AIBDC 008788

Designer/Maker/Manufacturer/Retailer

Celanese (fibre and fabric manufacturer)

Production country of the garment and components

UK

Production date

1944–52

Description

A pink CC41 Utility mark labelled teddy slip with pencil straps, an under pleat shaped bust, diamond cut under bust with bias cut body and buttons on the gusset.

Context

The printed label states CC41 1101/1. The CC41 denoted best value, reliable goods that met the UK's government's austerity regulations. According to the Statutory Rules and Orders published by His Majesty's Stationery Office, 1943, any number starting with a 1 denoted a rayon. 1101 was introduced in 1942. The suffix /1, which denoted a dyed fabric (/2 would denote a printed fabric) was added in 1944, so this fabric dates from between 1944 and 1952, when use of the Utility mark ceased. Acetate rayon was used as a more affordable option to silk. The slip was made in a factory for sale in a shop.

Labels/Inscriptions

Printed on woven labels sewn into a side seam: CC41 1101/1 MADE FROM A 'Celanese' UTILITY FABRIC. Use cool iron. / B.S.36 Designed for Bust: 36/37".

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Filament, twisted
Fabric construction:	Woven
Garment Construction:	Stitched

Material

Acetate rayon (Trade name: Celanese) with cotton overlock thread

Measurements

Length centre back: 92cm

Source

Purchase

More information on this object

https://www.modip.ac.uk/artefact/aibdc-008788

7.

Jacket of printed woven viscose rayon with Utility Mark label

See section 92.9 Viscose rayon

Object number

MoDiP: AIBDC 000824

Designer/Maker/Manufacturer/Retailer

Unknown

Production country of the garment and components

UK

Production date

circa 1942–52

Description

Utility mark labelled jacket, with three-quarter length sleeves, popper front fasteners beneath five fabric covered false buttons, simulated belt, and shoulder pads. The multi-coloured print is based on the traditional paisley design, its busy pattern allowing unmatched joins, thereby reducing material wastage. One of the shoulder pads has a completely different material patch on the underside.

Context

The CC41 label denoted best value, reliable goods that met the UK government's austerity regulations. According to the Statutory Rules and Orders published by His Majesty's Stationary Office, 1942, any number starting with a 1 denoted a rayon. 1105 was specifically an 'All viscose Marocain' intended as a dress fabric. The suffix /2 denotes it is a printed fabric.

Labels/Inscriptions

Printed on a woven label sewn in at nape of neck: CC41 1051/2 44.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Filament, twisted
Fabric construction:	Woven
Garment Construction:	Stitched

Material

Viscose rayon

Measurements

Length centre back: 65cm

Source

Purchase from a second-hand shop

More information on this object

https://www.modip.ac.uk/artefact/aibdc-000824

8.

Jacket from a pair of Luvisca pyjamas of a woven viscose rayon and cotton blend

See section 3 Viscose rayon

Object number

Westminster Menswear Archive: WMA.2019.147.1

Designer/Maker/Manufacturer/Retailer

Courtaulds (fabric); fabric retailed under trade name Luvisca

Production country of the garment and components

Unknown

Production date

Probably 1950–60

Description

Blue and white striped pyjama jacket (part of a pair of pyjamas). It is made of Luvisca, a fabric made of cotton and rayon yarns. The vertical stripes are a mix of broad pale blue and narrower stripes of mid and dark blue all edged with narrow white stripes. The jacket has a turn down collar and fastens centre front with three opaque white plastic buttons. It has a small opaque white plastic button at the collar which fastens with a loop (possibly added later). On the left chest is a patch pocket with a pointed welt with the stripes placed horizontally. Label in the form of a hanging loop in the back of the neck in red lettering on white with an emblem of a red button in a black circle with 'TESTED QUALITY' around the outside. Size 40.

Context

Advantages of the cotton viscose rayon blend are that the former has much better wet strength than the latter and thus increases the washability of the garment. Whereas the viscose rayon makes the fabric less prone to wrinkling than pure cotton and drapes better. It is also capably of greater depth of colour.

Labels/Inscriptions

Label: Luvisca / REGD.

Methods

Fibre manufacture:	Farmed (cotton); extruded (viscose rayon)
Yarn manufacture:	Spun
Fabric construction:	Woven
Garment Construction:	Stitched

Material

Viscose rayon and cotton blend

Measurements

Length: 67cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2019-147-1


9.

Playtex Living Bra of knitted polyester, nylon, elastane and woven cotton

See section 3 Elastane; Nylon

Object number

MoDiP: AIBDC 000255

Designer/Maker/Manufacturer/Retailer

Playtex (manufacturer)

Production country of the garment and components

Unknown

Production date

Probably 1960–70

Description

A black Playtex Living Bra, Style no. 1261, Size 40b, with 'crisscross' front, bias-cut side panels, a long back line to hip and a double row of 7 metal hook and eye fasteners. Playtex introduced the Living Bra in the late 1940s, but this example includes elastane, not made in commercial quantities until 1959, thus it cannot date to before then. There are four sections of side boning, probably nylon, with cotton lining and V-shaped panels at the front. The straps are only elasticated at the point at which they join the bra. Side locks, probably also of nylon, connect the straps to the top of the bra cups. Complete with original illustrated box, stating that it includes Spandex Elastic made without rubber.

Context

Playtex was created in 1947, the name a fusion of the words, 'play' and 'latex'. In 1955, the year commercial television was introduced in Britain, it was the first brand to mention lingerie in a television commercial. Elastane has the potential to stretch and then return to its original shape. Also known by tradenames Spandex and Lycra, it has transformed the construction of under garments and is a material widely used in fashion where a degree of permanent elasticity is required.

Labels/Inscriptions

Printed on a woven label sewn into a side seam: Playtex® STYLE 1261 SIZE 40B.

Methods:

Fibre manufacture:	Farmed (cotton); extruded (polyester; nylon; elastane)
Yarn manufacture:	Staple, spun
Fabric construction:	Woven (cotton); knitted (polyester; nylon; elastane)
Garment Construction:	Stitched

Material

Polyester (main fabric); nylon (lace effect); elastane; cotton (lining and straps)

Measurements

Under bust: 73cm

Source

Gift

More information on this object

https://www.modip.ac.uk/artefact/aibdc-000255


PLAYTEX
Living
BRA
LONG LINE
£1
Wonderlastic spandex—
made without rubber—
lasts and lasts!
Exclusive!
"Magic Midriff"


New !
Wonderlastic Elastic
—a Spandex Elastic
made without rubber !
Keeps its life
month after month.
Can be
machine-washed,
.....it won't pucker
or stretch out like
ordinary elastic.
Exclusive elastic
Magic - Midriff
gives the
smoothest bust-
to-hip line ever.
Elastic criss-
cross front lets
you reach and
stretch freely.
Bias-cut elastic
side panels
move with you,
breathe with
you.
PLAYTEX
Living
BRA
LONG LINE

10.

Burton man's suit of woven wool and Acrilan™ acrylic blend lined with viscose rayon

See section 3 Acrylic; Viscose rayon


Object number

Leeds Museums and Galleries: LEEDM.S.1987.0011.3

Designer/Maker/Manufacturer/Retailer

Burton

Production country of the garment and components

UK

Production date

1958

Description

Jacket from a man's two-piece suit made of dark grey wool blended with Acrilan. Single-breasted fastening with three buttons.

Context

Burton was probably the most significant of Leeds's multiple tailors. Established in the early 1900s it mass-manufactured both made-to-measure and ready-to-wear tailoring. Burton shops could be found on the high street of most major towns and cities across Britain. Synthetics start to appear in men's tailoring in the 1950s, either blended with wool or used on their own. Acrilan, a registered name for an acrylic fibre developed in 1949, was commercially produced from 1954 onwards. Acrylic fibres added strength to the softness of the wool, making the suit harder wearing. Manufacturers advertised that synthetic fabrics helped to make suits moth resistant and crease resistant, and that fixed creases (i.e. trouser creases) would hold better and longer.

A factory order label on the inside of the pocket dates the suit to 1958. The label shows that it was a made to measure suit. This is a more efficient method of production than a bespoke suit but it is still more expensive than a ready to wear, off the peg suit. Burton was very much about making well-made suits for the ordinary man.

Labels/Inscriptions

Woven label on internal pocket: BURTON tailored Wool blended with ACRILAN.

Methods

Fibre manufacture:	Farmed (wool); extruded (acrylic; viscose rayon)
Yarn manufacture:	Spun
Fabric construction:	Woven
Garment Construction:	Stitched

Material

Acrylic (Trade name: Acrilan) and wool blend; viscose rayon (lining)

Measurements

Length centre back: 79cm

Source

Gift

1960s

11.

Hugh Walker Collection woman’s suit of woven viscose rayon lined with acetate rayon

See section 3 Viscose rayon; Acetate rayon

Object number

Leeds Museums and Galleries: LEEAG.2010.0101

Designer/Maker/Manufacturer/Retailer

Hugh Walker (designer and manufacturer of suit); Moygashel Ltd. (manufacturer of textile)

Production country of the garment and components

UK

Production date

circa 1960

Description

Woman’s suit in a coarse woven textile. Short sleeves with scallop neck. Trimmed with two plastic buttons on the waist and knee length straight skirt. Two shop labels still attached state it is a "Hugh Walker collection" and is made of "Moygashel fabric".

Context

Moygashel Ltd. was a linen mill based in Moygashel, County Tyrone, Ireland, with a reputation for making quality cloth. It was part of a group consisting of several companies, including Braidwater Spinning Co. and Smyth's Weaving Factory. It produced a wide range of fabrics with the percentage of linen falling as synthetic fibres such as polyester, acrylic and rayon were used. According to the FTIR analysis both the warp and weft of the material of this suit is made of viscose rayon.

Designs were bought from several independent designers as well as from Ken Bloomfield, the in-house designer. The garments were sold through home shopping catalogues. In 1969 the company was bought by Courtaulds. For information about the company see: https://www.nmni.com/collections/history/sound-and-visual-media-archives/living-linen/hoyfmr200075.

Hugh Walker was a clothing manufacturer based in London

Labels/Inscriptions

Two printed card labels attached outside waist: 'From The HUGH WALKER Collection LONDON W1' and 'IN A MOYGASHEL fabric'.

Methods

Fibre manufacture: Extruded

Yarn manufacture: Spun

Fabric construction: Woven

Garment Construction: Stitched

Material

Viscose rayon (outer); acetate rayon (lining)

Measurements

Jacket centre back: 96cm

Source

Unknown

12.

Suit of woven Crimplene™ polyester and lurex

See section 3 Polyester

Object number

Leeds Museums and Galleries: LEEAG.2011.0198

Designer/Maker/Manufacturer/Retailer

ICI (manufacturer of cloth)

Production country of the garment and components

UK

Production date

circa 1960

Description

Woman's suit of a jacket and skirt in a pale green chevron-ribbed crimplene and lurex. Tailored jacket, unlined and fastening with four metal buttons. Skirt, straight, just below knee length, unlined with elasticated waist. A card label includes the inscription 14/10/0 which may indicate the price: £14-10s-0d.

Context

Crimplene is the tradename of a polyester yarn that was first launched in 1959. It is a modified version of Terylene. The patent rights were sold to Imperial Chemicals Industries Ltd. (ICI) in 1960. Marketed as a convenient fabric due to its crease resistant, quick drying, wash and wear properties, it was popular throughout the 1960s.

Lurex is a yarn made from a thin strip of aluminium sandwiched between two plastic films invented in 1946. It is lighter weight than lamé, does not tarnish, and is strong enough to be used in power looms to make complex woven fabrics, making new metallic fabrics such as this one possible.

Labels/Inscriptions

Woven label inside jacket back neck: MADE FROM Crimplene (ICI) wash tub 4 symbol SIZE 12 TO FIT Hips 36 Bust 34.

Card label inside jacket back neck: Crimplene ICI - with care instructions; shop label - style/stock number - 14/10/0.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Spun
Fabric construction:	Woven
Garment Construction:	Stitched

Material

Polyester (Trade name: Crimplene); lurex

Measurements

Jacket length centre back: 55cm

Source

Unknown

13.

A pair of Brettles knickers of knitted Bri-nylon™, a nylon and wool blend

See section 3 Nylon


Object number

MoDiP: AIBDC 008797

Designer/Maker/Manufacturer/Retailer

Brettles (manufacturer)

Production country of the garment and components

UK

Production date

1960s

Description

A pair of cream women's long leg, high waisted knickers made by Brettles of circular, pointelle pattern, knitted construction with inset gusset.

Context

The Brettles of Belper company dates to the early nineteenth century and is said to have supplied silk stockings to Queen Victoria (1819–1901). The company has since been owned by Courtaulds, Chilprufe and Slenderella. Both wool and nylon are moisture-wicking and dry quickly, although nylon dries faster than wool. Wool tends to be itchy which is mediated by the nylon content. Nylon is harder wearing than wool thus extending the garment's life. The sewn-on paper price label indicates that it was originally sold for 12/11 (twelve shillings and eleven pence), a relatively high price.

Labels/Inscriptions

Printed on swing tag attached to waist: Brettles WOOL and BRI-NYLON MADE IN ENGLAND WASHING HINTS - USE LUKEWARM WATER AND SOAP FLAKES. RINSE AND STRETCH INTO SHAPE. DO NOT IRON.

Woven label sewn into waist: Brettles WOOL & BRI-NYLON MADE IN ENGLAND. W

Handwritten paper tag sewn to waist: SB 1064 RG/- Grace W 12/11.

Methods

Fibre manufacture: Farmed (wool); extruded (nylon)

Yarn manufacture: Staple, spun

Fabric construction: Knitted

Garment Construction: Stitched

Material

Nylon (Trade name: Bri-nylon) and wool blend

Measurements

Length: 54cm

Source

Purchase

More information on this object

https://www.modip.ac.uk/artefact/aibdc-008797

14.

Fake fur jacket of Courtelle™ acrylic and modacrylic, lined with acetate rayon with cotton pocket stabilisers

See section 3 Acrylic; Modacrylic

Object number

MoDiP: AIBDC 000261

Designer/Maker/Manufacturer/Retailer

Unknown

Production country of the garment and components

Probably UK

Production date

1960–80

Description

A short, lined, dark brown lustrous pile fabric (fake fur) jacket with long sleeves and two heavy plastic buttons with textured tops, front fastening, half belt and side pockets. The pile is densely threaded and gives the impression of pelts stitched together. The item requires specialist dry cleaning. The shortness of the jacket dates it on style grounds to the 1960s however there are signs it has been altered. It could have been cut down from a three-quarter length jacket, a style typical of the 1970s, making it an upcycled garment with an implication of two owners. These factors suggest that it was considered a luxury item.

Context

Polymeric fibres have been used to imitate fur since the late 1920s but technological improvements, together with the introduction of acrylic, provided a better-quality substitute from the mid-1950s. Pile fabrics typically consist of synthetic fibres pushed through a base fabric and melted into position.

Labels/Inscriptions

Two printed and one woven label sewn into a side seam (some lettering obscured by seam):
Label 1: COURTELLE ® and modacrylic [? in ord]er to keep this garment looking luxurious and […?e] … [?ex]posure to direct heat …[?]tting in the garment and disturbing its [?]le … Also necessary to [?sh]ake the garment thoroughly after ra[?in] … [?s]tore on a coat hanger [?u]se furrier cleaning method when requ[ired].
Label 2: IMPORTANT DO NOT DRY CLEAN DO NOT STEAM OR HEAT THIS GARMENT CLEAN ONLY BY THE FURRIERIZED METHOD OF FURCLEAN LTD. 3, BELSIZE PLACE, LONDON, N.W.3. 01-794 3242 & 3243 SUEDES LEATHER & SHEEPSKINS.

Methods

Fibre manufacture:	Farmed (cotton); extruded (acrylic and modacrylic)
Yarn manufacture:	Staple, spun (backing; lining); cut to length (imitation fur)
Fabric construction:	Woven (backing, lining); fibres embedded in woven backing (imitation fur)
Garment Construction:	Stitched

Material

Acrylic (Trade name: Courtelle) (backing); modacrylic (imitation fur); cellulose acetate (lining); cotton (pocket stabilisers)

Measurements

Length centre back excluding collar: 72cm

Source

Gift

More information on this object

https://www.modip.ac.uk/artefact/aibdc-000261

15.

Alexandre Ltd. man's suit of woven nylon lined with Milium, a blend of viscose rayon and metal thread

See section 3 Nylon; Viscose rayon

Object number

Leeds Museums and Galleries: LEEAG.2012.0285

Designer/Maker/Manufacturer/Retailer

Alexandre Ltd. (designer and manufacturer)

Production country of the garment and components

UK

Production date

1960–70

Description

Jacket from a man’s two-piece suit of blue-grey twill with white pinstripe. Jacket fastens with 3 grey buttons; narrows at waist; two side pockets with flaps; one external breast pocket; one internal breast pocket with button. Both warp and weft threads from this garment were found to be nylon by FTIR analysis. The use of these relatively new synthetic fibres was a fashion trend, partly down to consumer demand. Lined with a grey synthetic satin with Milium.

Context

Milium fabric — a viscose rayon lining fabric woven with metallic thread for added insulation. Manufactured by Deering Milliken USA and advertised in *Life* magazine from 1950 onwards.

Labels/Inscriptions

Woven label on internal breast pocket: ALEXANDRE   Shape fast tailoring   LINED WITH Milium.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Spun
Fabric construction:	Woven
Garment Construction:	Stitched

Material

Nylon (outer); viscose rayon (lining)

Measurements

length centre back: 76cm

Source

Unknown

16.

Emilio Pucci trousers of knitted nylon (polyamide)

See section 3 Nylon

Object number

V&A: T.585:2-1995

Designer/Maker/Manufacturer/Retailer

Emilio Pucci (designer)

Production country of the garment and components

Italy

Production date

1965

Description

A pair of form-fitting trousers in brightly coloured printed polyamide (nylon), complete with integral feet. Each leg is made from one pattern piece, joined at the centre front and shaped to the leg and backside with a seam along the centre back of each leg from ankle to waist. The leg pattern pieces stop above the ankle where the feet begin. Each foot is made with one pattern piece, sewn along the bottom of the foot from the toe up to the shin. The trousers have a separate waistband in the same fabric sewn on at the top, and a diamond-shaped gusset insert.

Context

Part of an ensemble with a silk shirt printed in the same pattern. The print was named 'Dalia 1'. Throughout his career Emilio Pucci (1914–92) worked closely with several textile manufacturers to develop new textiles for clothing and improve dyeing techniques.

He was enthusiastic in adopting synthetics alongside silk. Here, nylon was likely chosen for its ability to maintain a form-fitting shape that would not sag or crease during wear.

Labels/Inscriptions

EMILIO PUCCI/ FLORENCE – ITALY.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Twisted
Fabric construction:	Knitted
Garment Construction:	Stitched

Material

Nylon (polyamide)

Measurements

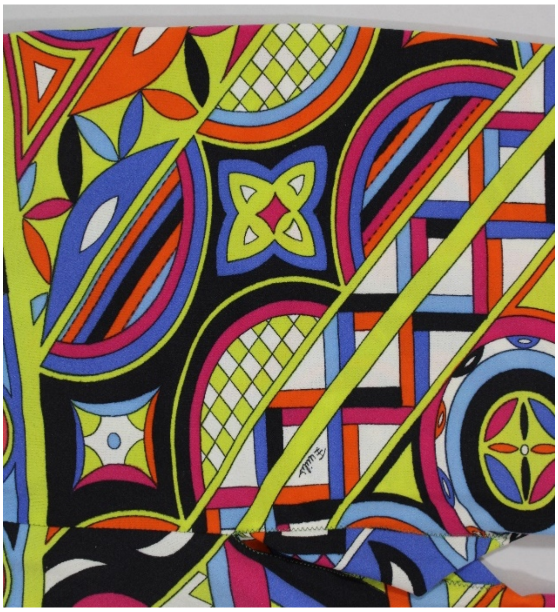
Unknown

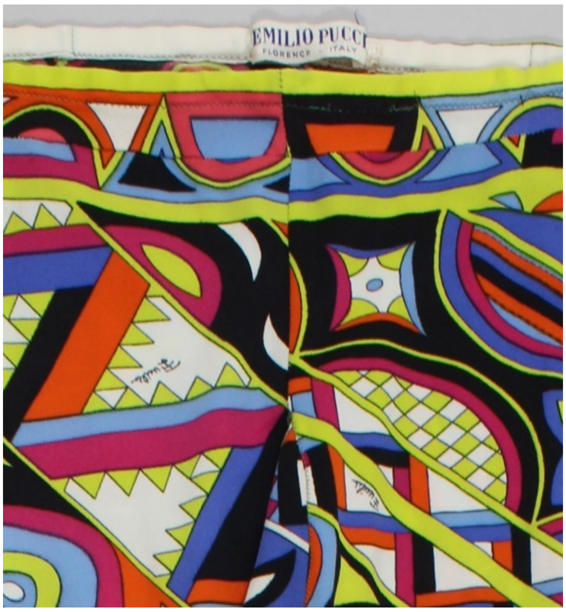
Source

Given by Mrs Veronica Cohen

More information on this object

https://collections.vam.ac.uk/item/O351201/trouser-suit-pucci-emilio/





17.

Ginger Group dress of woven viscose rayon

See section 3 Viscose rayon

Object number

V&A: T.215-1987

Designer/Maker/Manufacturer/Retailer

Mary Quant/Ginger Group (designer)

Production country of the garment and components

Britain

Production date

1966

Description

A mini dress in a polo shirt style with contrasting collar and metal zip opening at the centre front, short sleeves and a welt pocket on each breast. The plain weave viscose rayon is quite rough feeling and has an appearance similar to linen, with some slubs.

Context

Mary Quant launched Ginger Group in 1963 as a lower-priced ready-to-wear range of fashionable womenswear. The linen-like viscose of this dress offered characteristics that would have been valued by the Ginger Group's consumers. It was easy to wash and dry and would not crease — unlike natural linen — making it an easy to wear and easy to care for garment.

Labels/Inscriptions

MARY QUANT'S ginger GROUP®/ MADE IN ENGLAND / 13.

Methods

Fibre manufacture:	Extruded, cut
Yarn manufacture:	Staple, spun
Fabric construction:	Woven

Garment Construction: Stitched

Material

100% viscose rayon

Measurements

Unknown

Source

Given by Mrs C. Archer

More information on this object

https://collections.vam.ac.uk/item/O365956/dress-quant-mary/

18.

Jacket from a Burton man's suit of wool blended with Terylene™ polyester lined with viscose rayon

See section 3 Polyester; Nylon; Viscose rayon

Object number

Leeds Museums and Galleries: LEEDM.S.1987.0011.4

Designer/Maker/Manufacturer/Retailer

Burton (designer, manufacturer, and retailer)

Production country of the garment and components

UK

Production date

1966

Description

Jacket from a man’s two-piece suit in a brown piece-dyed Glen check wool and Terylene blend. Jacket is single breasted fastening with three buttons. Factory order labels on inside of the pocket date the suit to 1966.

Context

The label shows that it is a made to measure suit. This is a more efficient method of production than a bespoke suit but is still more expensive than a ready-to-wear, off the peg suit. Burton was very much about making well-made suits for the ordinary man. For more about Burton and the benefits of using synthetic fibres please see number 11.

Terylene is the registered name for a polyester patented in Britain in 1941; commercially available for some products from October 1952. The FTIR analysis suggested the possibility of some nylon being included in the blend.

Labels/Inscriptions

Woven label on internal breast pocket: BURTON tailoring wool BLENDED WITH 'TERYLENE'.

Methods

Fibre manufacture:	Farmed (wool); extruded (polyester; cellulose acetate)
Yarn manufacture:	Spun
Fabric construction:	Woven
Garment Construction:	Stitched

Material

Wool blended with polyester (trade name: Terylene); viscose rayon

Measurements

Jacket chest: 101cm

Source

Gift

1970s

19.

Frank Usher maxi dress of a Tricelon™ triacetate and nylon blend

See section 3 Nylon; Triacetate


Object number

MoDiP: AIBDC 002765

Designer/Maker/Manufacturer/Retailer

Frank Usher (designer and manufacturer of garment); Courtaulds (manufacturer of fabric)

Production country of the garment and components

UK

Production date

1970s

Description

A maxi dress in printed Courtaulds' Tricelon, a mix of 65% triacetate and 35% nylon. Consisting of a vertically striped shirt style bodice with kimono sleeves bearing a floral print in the same colours as the bodice, trimmed with a broad band of the striped fabric. The full pleated skirt is made from the floral print fabric which terminates in horizontal stripes, all on a cream ground. Good seam allowances. Finished with a 50mm wide fabric belt with a large round metal buckle covered in the same material. The belt is backed with imitation leather, probably PVC. The fabric side of the belt has experienced some discolouration along the seams and wrinkling along the entire length, possibly a reaction between the different materials.

Context

The Frank Usher brand began business in London in 1946 and offered catwalk inspired design and detail at affordable prices. This blend of 65% triacetate and 35% nylon allowed the designer to accomplish different functional requirements. The nylon enabled the dress to be washed at home (instead of needing to be dry cleaned), provided durability, crease and shrink resistance. The triacetate has a silk-like glossy sheen with a good drape that lends the dress a high-quality appearance.

Labels/Inscriptions

Woven label sewn to nape of neck: Frank Usher LONDON MADE IN ENGLAND.
Three further printed woven labels sewn to the manufacturer's label read: 40 / Dry-clean or Hand wash in mild soap suds in lukewarm water without rubbing or twisting Dry flat. Coloured or printed fabrics should be tested for dye fastness as recommended on your washing powder pack. We do not recommend the use of detergents. Commercial dry clean P / COURTAULDS Tricelon 65% TRIACETATE 35% NYLON, with further machine and hand washing instructions.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Filament, twisted
Fabric construction:	Woven
Garment Construction:	Stitched

Material

65% triacetate 35% nylon (cloth)

Measurements

Length centre back: 155 cm

Source

Gift

More information on this object

https://www.modip.ac.uk/artefact/aibdc-002765


Frank Usher
LONDON
MADE IN ENGLAND
65%TRIAC
35%NYLON
MACHINE
Warm (40°C)
minimum wash
HAND WASH
Warm
(40°C)
Cold rinse. Short spin.
Do not wring
6
40°
Cool iron, reverse side, damp
679

20.

Cardigan of Courtelle™ acrylic

See section 3 Acrylic

Object number

MoDiP: AIBDC 000252

Designer/Maker/Manufacturer/Retailer

High Cross (manufacturer); Courtaulds (yarn)

Production country of the garment and components

UK

Production date

circa 1970–80

Description

A women's light blue machine knitted cardigan made from Courtelle acrylic fibre. The cardigan has long sleeves and front fastening up to the neck with buttons. The eight buttons are made of plastic, probably polyester.

Context

Courtelle is a Courtaulds trademarked acrylic yarn introduced in 1967. Used as a cheaper substitute for wool, it feels warm and soft to the touch but is quicker drying, thus easier to wash, and moth proof. Like wool it is prone to pilling.

Labels/Inscriptions

Machine embroidered on woven label sewn to inside back neck: High Cross. FULLY FASHIONED IN COURTELLE REGD WARM WASH ONLY BY HAND, LINE DRY, COOL IRON, DRY.

Printed on a shaped card swing tag: Containing COURTELLE Regd. acrylic fibre. This swing ticket is for use in conjunction with a Courtelle sew on label. Courtelle is the Registered Trade mark for Courtaulds acrylic fibre.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Staple, spun
Fabric construction:	Knitted
Garment Construction:	Stitched

Material

Acrylic (Courtelle)

Measurements

Length centre back: 64cm

Source

Gift

More information on this object

https://www.modip.ac.uk/artefact/aibdc-000252

21.

Gabardine coat of Terylene™ polyester and wool blend lined with nylon

See section 3 Polyester; Nylon

Object number

MoDiP: AIBDC 003729

Designer/Maker/Manufacturer/Retailer

Connolly Creations (manufacturer); British Caledonian (manufactured for)

Production country of the garment and components

UK

Production date

1970–80

Description

A long densely woven (gabardine) machine washable navy coat made as part of a British Caledonian air stewardess uniform, front opening with 5 buttons probably polyester, belt, epaulettes, sleeve straps and a detachable hood. The belt and sleeve straps have plastic buckles with imitation stitching reminiscent of leather buckles. Both the warp and weft fibre samples were found to be polyester by FTIR analysis, but the feel of the garment is such that, nonetheless, we are inclined to believe, as the label states, that the coat is made of a wool and polyester blend.

Context

British Caledonian was a British private independent airline which operated out of Gatwick Airport in south-east England during the 1970s and 1980s.

Gabardine is a tightly woven fabric with a twill weave, invented by Thomas Burberry (1835–1926), of the firm Burberry, created in 1879 and patented in 1888. It has many more warp than weft fibres, the latter lying entirely unseen at the back, enabling the use of inferior quality fibres.
Blending polyester with wool makes the fabric lighter in texture, better in wrinkle recovery, firmer in wear resistance, easier to wash, more stable in size, and less susceptible to damage from insects.

Labels/Inscriptions

Machine embroidered on woven label sewn to centre back inside collar: Made in England.
Machine embroidered on woven label attached to lining: TAILORED EXCLUSIVELY FOR British Caledonian BY CONNOLLY CREATIONS D.E.C (CLOTHING) Ltd. IN ENGLAND LONDON – NEW YORK.
Printed on woven labels sew into lining on right side seam, label 1: TERYLENE POLYESTER 55% terylene 45% wool worsted with care graphics indicating it can be washed at 40% or dry cleaned.
Label 2: Lining 100% Nylon

Methods

Fibre manufacture:	Farmed (wool); extruded (polyester; nylon)
Yarn manufacture:	Staple, spun (outer); filament, twisted (lining)
Fabric construction:	Woven
Garment Construction:	Stitched

Material

Outer: 55% polyester (Trademark: Terylene) 45% wool (outer); 100% nylon (lining)

Measurements

Length centre back including hood: 143cm

Source

Gift

More information on this object

https://www.modip.ac.uk/artefact/aibdc-003729

22.

Biba dress of knitted acrylic

See section 3 Acrylic

Object number

V&A: T.203-1991

Designer/Maker/Manufacturer/Retailer

Biba (Barbara Hulanicki designer)

Production country of the garment and components

Britain

Production date

1973

Description

Dress of knitted acrylic jersey, printed with an Art Deco inspired design in black and cream. A high collar and full length fitted sleeves, puffed shoulders, a fitted bodice and skirt flared from the hips. Self-covered button fastenings at the centre front and cuffs. The fine, machine-knitted jersey has developed a slight nap, with small cream fibres visible across the surface (see photograph below).

Context

Here, the knitted acrylic jersey is mimicking the appearance and qualities of wool. Acrylic was and still is a popular alternative to wool as it is simpler to wash with much less risk of shrinkage than conventional sheep's wool.

Labels/Inscriptions

Unknown.

Methods

Fibre manufacture: Extruded, cut

Yarn manufacture: Staple, spun
Fabric construction: Knitted
Garment Construction: Stitched

Material

100% acrylic (polyacrylonitrile with either vinyl acetate or methyl acrylate)

Measurements

Length: 124cm

Source

Given by Karina Garrick

More information on this object

https://collections.vam.ac.uk/item/O120579/maxi-dress-biba/

1980s

23.

Berghaus Alpine Extrem Gore-Tex parka with nylon shell

See section 3 Nylon

Object number

Westminster Menswear Archive: WMA2017.166

Designer/Maker/Manufacturer/Retailer

Berghaus (designer and manufacturer)

Production country of the garment and components

Great Britain

Production date

Probably 1980–89

Description

Aqua green and dark blue Gore-Tex parka or coat with bright blue hood and underarm accents. It has two zipped angled pockets below the waist and one flapped angled pocket on the left chest with Berghaus badge. Fastens centre front with blue 'SALMI' double headed zip and black hook and loop fastener storm flap. The hood is wired and there are drawstrings at waist and hem. Black hook and loop fastening patches to cuffs. Some of the interior seam taping is missing or loose. Care label in inside of left zip pocket.

Context

Gore-Tex is a thin, flexible, waterproof, breathable membrane of polytetrafluoroethylene (PTFE) containing minute holes. The Gore-Tex website claims each square inch has nine billion pores. Each of these tiny holes is 20,000 times smaller than a water droplet. This is what makes the membrane waterproof. A related well-known brand name of a PTFE-based composition is Teflon.

Labels/Inscriptions

Label: berghaus / Made in Gt. Britain / Size: Medium / ALPiNE EXTREM / fabric: 100% Nylon shell / bonded to GORE-TEX membrane.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Spun
Fabric construction:	Woven, bonded
Garment Construction:	Stitched

Material

100% Nylon (shell) bonded to polytetrafluoroethylene

Measurements

Length: 79cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2017-166

24.

Jacket from a Hepworths man's suit of woven polyester partly lined with nylon

See section 3 Polyester; Nylon

Object number

LEEAG.2020.0034.0002

Designer/Maker/Manufacturer/Retailer

Hepworths (designer, manufacturer [probably] and retailer)

Production country of the garment and components

UK (suit); Italy (cloth)

Production date

circa 1980

Description

Jacket from a man’s two-piece suit of silver or grey polyester. The jacket fastens with 3 buttons and is only part lined on the front with no lining on the back. The suit is labelled on the inside of the jacket as being 'Wash and Wear'. There is a manufacturer’s label for Hepworths along with a 'made in Italy' label. It is likely that this refers to the cloth used for the suit as the suit was probably made in the Hepworths’s factory, in Leeds. Warp and weft samples were both found to be polyester and the lining nylon by FTIR analysis. The use of the term ‘viscose’ on the label is unexplained.

Context

This suit belonged to Donald Naylor, a driver for Hepworths for 35 years until 1984. As an employee he could have a new suit at a very reasonable price every couple of years. This suit can be washed. Advances in synthetics in the 1950s led to the development of ‘Wash and Wear’ suits.

Labels/Inscriptions

Woven inside jacket front: Hepworths Made in Italy POLYESTER VISCOSE WASH AND WEAR.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Spun
Fabric construction:	Woven
Garment Construction:	Stitched

Material

Polyester (outer); nylon (lining)

Measurements

Length centre back: 76cm

Source

Gift

25.

Stone Island Marina Jacket of cotton with styrene-butadiene rubber elbow pads

See Section 3 Styrene-butadiene

Object number

Westminster Menswear Archive: WMA.2017.012

Designer/Maker/Manufacturer/Retailer

Stone Island

Production country of the garment and components

Italy

Production date

1988

Description

Red printed cotton jacket with black moulded rubber patches on each elbow imprinted with the Stone Island compass emblem. It has a turn down collar in dark cream beige cotton and fastens centre front with three visible black metal buttons and three hidden metal press studs. Two large rectangular patch pockets at the front chest with openings to the outer side edge strengthened with bar tacks. The cuffs fasten with one black button and there are two black buttons to the upper left shoulder for a Stone Island badge (missing). The upper back in inscribed 'Stone Island Marina' in white - probably discharge printed. Four thin white stripes around the bottom edge and cuffs - probably discharge printed. Large button fastening with poppers on the lower half. No lining, the cotton cloth is white on reverse. Label in upper inside centre back: Stone Island Piece no. 1161024. Size: Extra Large.

Context

Styrene-butadiene rubber is the highest volume general-purpose synthetic rubber in production today. It is manufactured from a copolymer of styrene and butadiene, and in many cases is used as a cost-efficient alternative to natural rubber. It is frequently used for car tyres.

Labels/Inscriptions

Label: STONE ISLAND / PIECE N. / 1161024.

Methods

Fibre manufacture:	Farmed (cotton); moulded (styrene-butadiene rubber)
Yarn manufacture:	Spun (cotton)
Fabric construction:	Woven
Garment Construction:	Stitched, moulded

Material

Cotton (jacket); styrene-butadiene rubber (elbow pads)

Measurements

Length: 78cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2017-012

26.

Stone Island thermosensitive ice suit: jacket and liner of nylon and polyester

See section 3 Nylon; Polyester

Object number

Westminster Menswear Archive: WMA.2016.299.1

Designer/Maker/Manufacturer/Retailer

Stone Island (designer); manufactured for Stone Island

Production country of the garment and components

Italy

Production date

1988

Description

Jacket made of yellow nylon coated with a resin with thermosensitve qualities. It has a turn down collar that contains a hood and a drawstring waist. It fastens centre front with a metal Lampo zip. There is a vertical flap that fastens with four metal press-studs to the top left chest and a horizontal flap of the same design to the right side above the waist. It has two large, flapped patch pockets to the hips that fasten with single metal press-studs. The waist drawstrings have rounded black stoppers and there are drawstrings around the hood and bottom hem. Label in back of neck, large care label to the inside right front. Detachable Stone Island embroidered black badge to the left upper sleeve that fastens to the jacket with two metal black buttons. There are scattered black marks on right front chest above press-stud flap caused by discolouration from the fabric reacting to the metal press studs.

The round-necked liner is made of olive-green polyester quilted in a diamond pattern. The collar, front edges, hem, and inside seams are bound in lighter green binding fabric. It fastens centre front with silver coloured metal buttons. The cuffs are knitted ribbing. It fastens to the jacket with a removable olive-green rope that is looped through eyelet holes in the liner and the jacket facings.

Context

This ice suit is constructed from a revolutionary fabric called Sway that was developed by the Japanese company Toray Industries. The material is coated with a resin that contains thermosensitive microcapsules, which change the colour from yellow to green in response to a cold environment.

Labels/Inscriptions

Label Jacket: c.p. company / 100% Polyamide / Made in Italy / 065E7020.
Label Liner: c.p. company / Esterno [External]: 100% Polyester / Interno [Internal]: 100% Polyester / Imbottitura [Filling]: 100% Polyester / Made in Italy.
066G9001.

Methods

Fibre manufacture:	Extruded (nylon; polyester); farmed (cotton)
Yarn manufacture:	Spun
Fabric construction:	Woven, bonded
Garment Construction:	Stitched

Material

Nylon (jacket: main fabric, padded inner binding); polyester (liner: main fabric, filler; jacket: outer coating under collar); cotton (jacket pocket lining)

Measurements

Jacket Length: 90cm
Liner Length: 80cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2016-299-1

1990s

27.

Bomber style jacket of Tyvek® polyethylene with nylon collar, cuffs and waist band

See section 3 Polyethylene; nylon

Object number

MoDiP: AIBDC 000947

Designer/Maker/Manufacturer/Retailer

Pride Products Inc. (manufacturer of garment); Dupont (manufacturer of Tyvek®)

Production country of the garment and components

Thailand

Production date

1990–2000

Description

A bomber style jacket made of Tyvek® with front zip, side pockets and black knitted collar, cuffs and waistband. It is printed with a pattern of dogs' heads. In a few places the Tyvek must have creased, and it has not printed. We have been unable to locate Pride Products Inc. but believe the garment may relate to American pride. The Pride Products Inc. label is printed over a stylised American flag.

Context

Tyvek® is a nonwoven material manufactured by Dupont. Polyethylene fibres are spun, entangled, and then heat and pressure bonded. It is lightweight and durable; breathable, yet resistant to water, abrasion, bacterial penetration and aging. It is widely used for protective garments.

Labels/Inscriptions

Two printed labels on textured Tyvek sewn into back of neck:

Label 1: Pride PRODUCTS INC.

Label 2: HAND WASH FOR LONGEST WEAR OR MACHINE WASH GENTLE CYCLE, COLD WATER HANG OR DRIP DRY ONLY DO NOT DRY CLEAN OR IRON MADE OF OLEFIN TYVEK® by DUPONT MADE IN THAILAND.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Spun
Fabric construction:	Pressure bonded (polyethylene); knitted (nylon)
Garment Construction:	Stitched

Material

Polyethylene (Trade name: Tyvek®) (body); nylon (collar, cuffs and waist band)

Measurements

Centre back: 70cm

Source

Purchase

More information on this object

https://www.modip.ac.uk/artefact/aibdc-000947

28.

Helen Storey Shirt of woven Tencel™ Lyocell

See section 3 Lyocell; Nylon; Elastane

Object number

V&A: T.228:1-1993

Designer/Maker/Manufacturer/Retailer

Helen Storey (designer); Courtaulds (manufacturer of textile)

Production country of the garment and components

Britain

Production date

Spring/Summer 1993

Description

A shirt top of classic shirt fit with front opening of 5 metal buttons and a pocket on the left breast. Loose sleeves gathered slightly at the cuffs. The shirt is gathered at the waist and connected to a leotard style bottom of polyamide and elastane. The Tencel™ lyocell fabric is very soft and relatively cool to the touch and has a heavy drape given the lightweight characteristic of the fabric.

Context

Helen Storey was the first British designer to be asked to trial Tencel™ lyocell after it was launched by Courtaulds in 1992. This top, and a pair of trousers made from the same fabric also in the collection of the V&A, were two of the first garments designed using Tencel™ lyocell.

Labels/Inscriptions

HELEN STOREY REAL CLASSICS LONDON. SMALL.

Methods

Fibre manufacture:	Extruded, cut
Yarn manufacture:	Staple, spun
Fabric construction:	Woven
Garment Construction:	Stitched

Material

100% Tencel™ lyocell (shirt), polyamide and elastane (gusset)

Measurements

Width: 60cm

Source

Given by the designer

More information on this object

https://collections.vam.ac.uk/item/O233660/trouser-suit-storey-helen/

29.

Janesville firefighter suit: jacket of aluminized aramid and liner of aramid, polyester and cotton

See section 3 Aramid; Polyester

Object number

Westminster Menswear Archive: WMA.2016.185.1

Westminster Menswear Archive: WMA.2016.185.3

Designer/Maker/Manufacturer/Retailer

Janesville (designer and manufacturer)

Production country of the garment and components

United States of America

Production date

1993

Description

Jacket made of aluminised Kevlar. It has a high stand collar that fastens across the neck from right to left with a wide tab and black hook and loop patches. It fastens centre front with a heavy metal zip and a wide placket over the length of the zip and a long black strip of hook and loop tape. The jacket has narrow adjustment tabs to each side at the hips. The inside cuffs have a narrow strip of black hook and loop tape on the inside edge and a snap fastener to attach the jacket liner. The inside of the jacket is made of a light brown loop fabric with a vertical stripe in light yellow thread, there are snap fasteners to the inside zip placket to attach the liner.

Liner made of cream fabric, with areas of brown discolouration, no collar and bound edges around the neck opening, fronts and hem. It has snap fasteners down each side to attach to the jacket. It is lined in blue fabric machine quilted in an ellipse pattern in white thread. The cuffs are finished on the inside with a narrow strip of black hook and loop tape to attach to the jacket. There are second mitten cuffs of knitted light yellow fabric with a large thumb opening.

It was not possible to get a measurement from the samples taken from this garment for analysis.

Context

Kevlar and Nomex are trade names of aramid. It is lightweight with outstanding strength-to-weight ratio, its tensile strength being equivalent to that of steel. It has good resistance to abrasion, and a very high melting point with low flammability.

Labels/Inscriptions

Jacket Label: Janesville / Division of Lion Apparel / WARNING / Do Not Remove this Label / This proximity protective garment meets the requirements of NFPA 1976, standard on protective clothing for proximity fire fighting, 1992 edition. / Questions write or call immediately: / Lion Apparel, Protective Systems Group / 3401 Park Center Drive / Dayton, Ohio 4514.

Outer shell: 67% Kevlar / 33% PBI Aluminized 7oz Size: 44 / 32 R Date: 9-2-93 Made in USA

Liner Label: Janesville / Division of Lion Apparel / WARNING / Do Not Remove this Label / This proximity protective garment meets the requirements of NFPA 1976, standard on protective clothing for proximity fire fighting, 1992 edition. / Questions write or call immediately: / Lion Apparel, Protective Systems Group / 3401 Park Center Drive / Dayton, Ohio 4514.

Thermal Liner Fabric: Nomex Aramid Quilt Moisture Barrier: Coated Polyester/Cotton Size: 44 / 32 R Date: 9-2-93 Made in USA.

Methods

Fibre manufacture:	Extruded (aramid; polyester) farmed (cotton)
Yarn manufacture:	Unknown
Fabric construction:	Woven
Garment Construction:	Stitched

Material

67% aramid / 33% aluminized (outer shell)

Aramid, polyester, cotton (liner)

Measurements

Jacket Length: 82cm; liner Length: 73cm

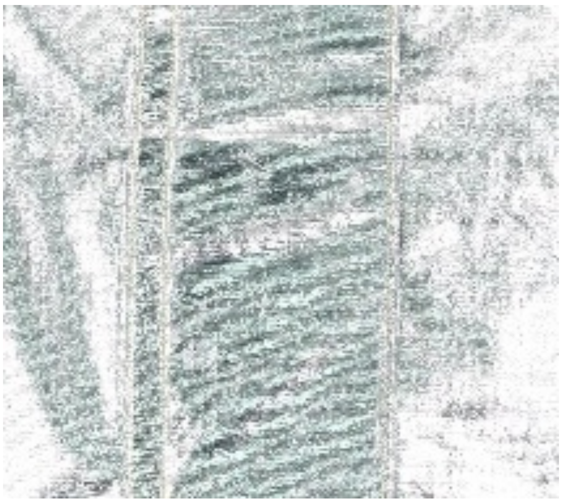
Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2016-185-1

https://westminster-atom.arkivum.net/2016-185-3



30.

Vexed Generation Neoballistic nylon Parka

See section 3 Nylon

Object number

Westminster Menswear Archive: WMA2018.48.1

Designer/Maker/Manufacturer/Retailer

Vexed Generation (designer); manufactured for Vexed Generation

Production country of the garment and components

England

Production date

1996

Description

Black hooded coat made of high tenacity nylon. The coat fastens centre front with a black Riri zip and hook and loop tape. The lower front panels, the centre back going up over the hood, and the whole of the bottom back of the coat feature herringbone shaped protective padding. The hood has lower flaps that can be closed over the face and fastened with hook and loop tape. The upper part of the hood opening is designed to be pulled tighter with a drawstring (missing). There are two large pockets on each breast which are curved at the top and fasten with black Riri zips and two pockets at the hips under the padding. The bottom of the coat is shaped so that it can be fastened through the legs with webbing and a buckle and there are two short pieces of black elastic at the bottom of each side seam. There is a hook and loop taped tabbed pocket on the left upper sleeve designed for a face mask (missing). Size M.

Context

Adam Thorpe and Joe Hunter set up Vexed Generation Clothing in 1993. Their urban street wear reflects their concerns about society, civil liberties and the environment. The parka is made from nylon 66, a high tenacity (neoballistic) fibre used in bomb blankets. It is waterproof, fire retardant and knife proof.

Labels/Inscriptions

Label: Vexed Generation / Made in England / +44 171 7295669 http://www.vexed.co.uk / M.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Spun
Fabric construction:	Woven
Garment Construction:	Stitched

Material

100% nylon

Measurements

Length: 103cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2018-48-1

31.

St Michael's label leatherette skirt of PVC with a nylon backing, lined with polyester

See section 3 Nylon; Polyester; PVC

Object number

MoDiP: AIBDC 001190

Designer/Maker/Manufacturer/Retailer

Marks & Spencer (designer and retailer)

Production country of the garment and components

Unknown

Production date

circa 1998

Description

A machine-washable, pewter-coloured, shiny leatherette skirt with side vent. The zip has been made into a feature and the hem is double stitched. The skirt is made of PVC on a nylon backing. Knitted nylon was coated with molten PVC and passed through rollers embossed with the skirt's surface texture. This process is called 'calendering'. The skirt cost £106.38 and has a matching top: AIBDC 001191.

Context

The nylon base layer provides elasticity to the garment. The rubbery coating alone would be more rigid. In use, this type of construction would have a short life span. It is likely that within three years cracks would start to appear, especially along fold lines such as the seams.

Labels/Inscriptions

Woven label sewn inside waist back right: St Michael FROM MARKS & SPENCER.

St Michael. Marks and Spencer. Made in the UK 4114 291. Machine washable. Fabric 74% PVC coated 26% polyamide. Lining 100% polyester.

Printed on woven label sewn into a side seam: T56/01225/5501 PEWTER (12/20) CAO 1295 C.I.F. A-37-002516 FABRIC 74% PVC COATED 25% POLYAMIDE LINING 100% POLYESTER (with care instruction graphics indicating wash at 40 degrees and no dry cleaning) IRON ON REVERSE SIDE (also in French, Portuguese, and German).

Printed swing label: St Michael FROM MARKS & SPENCER (repeated in French, Spanish, Portuguese, German and Dutch on the back) © MARKS & SPENCER p.l.c. 96 BAKER STREET. LONDON CA 01295 C.I.F A-3700 2516.

Methods

Fibre manufacture:	Melted (outer material); extruded (base layer and lining)
Yarn manufacture:	Spun (base layer and lining)
Fabric construction:	Calendered (finished outer layer); knitted (base layer); woven (lining)
Garment Construction:	Stitched

Material

PVC on nylon backing (skirt); polyester (lining)

Measurements

Length centre back: 50cm

Source

Purchase

More information on this object

https://www.modip.ac.uk/artefact/aibdc-001190

32.

Levi's Engineered Jeans Twisted full-length coat of a cotton and lyocell blend with detachable lining of a wool and polyester blend

See section 3 Lyocell; Polyester

Object number

Westminster Menswear Archive: WMA.2017.090

Designer/Maker/Manufacturer/Retailer

Levi’s (designer); Levi Strauss & Co. Europe (manufactured for)

Production country of the garment and components

Tunisia

Production date

Probably 2000–2010

Description

Blue denim coat with turn down collar and detachable grey fleece liner. It has a wide collar with a round neck and fastens centre front with four large grey metal buttons. There is an angled pocket to the left chest with a pointed flap on the outside that fastens with a metal press-stud, jetted slit and patch pocket to the inside with stitching showing on the outside. The coat has two large side pockets at hip level with vertical curved flaps fastening with metal press-studs. The pockets are inserted into the twisted side seams. Wide turn up cuffs with black rib knitted inner cuffs. The arm seams are twisted and the back of the coat has a wide yoke with two vertical back seams. Label in the back of the neck. Care label in left side seam with two extra buttons sewn into it.

The sleeveless liner is made of grey fleece, which has worn around the hip level. The edges are finished with grey binding and the liner is attached to the coat with flat metal buttons around the front edges and collar. They fasten into buttonholes and tabs of the coat facings. Care label in left side seam.

The percentages of lyocell (30%) and cotton (70%) given on the coat's label are interesting in the light of the measurements taken from the samples which found the weft to be lyocell and the warp cotton. The single sample taking from the lining found it to be polyester. It is likely however had further samples been taken they would have corroborated the presence of wool.

Context

Levi's introduced its Engineered Jeans with twisted seams in 1999. The innovation grew out of a recognition that regular 501 jeans developed a leg twist to the left due to the righthand twill fabric. The twisted seams created a more ergonomic fit.

Levi's marketing stresses correctly that Lyocell is created using environmentally responsible production processes. Blending it with cotton creates a softness hard to obtain otherwise. The downside is that while both lyocell and cotton are recyclable, blended fabrics are problematic and cannot be commercially recycled at present.

Labels/Inscriptions

Coat Label: Levi's® ENGINEERED JEANS™ / LARGE / www.levi.com.

Coat Care label:70% Cotton / 30% Lyocell-Tencel / Made in Tunisia / 70102 0835 L / 37953 3400 0835 / Levi Strauss & Co. Europe / 15-23 Ave. A. Fraiteur / Brussels, Belgium.

Liner Care Label: 80% Wool / 20% Polyester / Made in Tunisia / 70102 0835 L / 37953 3400 0835 / Levi Strauss & Co. Europe / 15-23 Ave. A. Fraiteur / Brussels, Belgium.

Methods

Fibre manufacture:	Extruded (lyocell; polyester) Farmed (cotton; wool)
Yarn manufacture:	Spun
Fabric construction:	Woven, knitted
Garment Construction:	Stitched

Material

70% Cotton 30% Lyocell (coat); 80% wool 20% polyester (liner)

Measurements

Coat length: 104cm; liner Length: 83cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2017-090

33.

C.P. Company dark green polyurethane coated Jacket

See section 3 Acrylic; Polyurethane

Object number

Westminster Menswear Archive: WMA.2018.115

Designer/Maker/Manufacturer/Retailer

C. P. Company

Manufacturer

Unknown

Manufactured for

Sportswear S.P.A. C. P. Company

Production country of the garment and components

Italy

Production date

2000

Description

Dark green coated jacket with roll collar and detachable C.P. Company patch. A large black metal Lampo zip with a black fabric puller forms the front closure. The jacket has top stitch detailing all over, including two lines either side of the zip and a double stitched hem. It has two pockets inserted into the side seams, finished with bar tacks and top stitching. The jacket is unlined, but the shell fabric is backed with a grey fleece-like cotton acrylic mix. The cuffs are finished with C.P. Company black matte press-studs. The black vinyl C. P. Company patch is attached with hook and loop tape just above the hem on the front left side.

Context

Condition: the entire outer surface of the polyurethane is breaking down and has become sticky. It is sticking to itself creating areas where the surface is no longer shiny.

Labels/Inscriptions

Label: C. P. / COMPANY / MADE IN ITALY.

Care label: SPORTSWEAR / COMPANY S.P.A. / 54% Cotton / 23% Acrylic / 23% Polyurethane SPW VIA CONFINE 2161 / RAVARINO (MO) ITALIA / ART. 3318M425 /BS / MADE IN ITALY / 03-530-4524.

Methods

Fibre manufacture:	Farmed (cotton); extruded (acrylic); polyurethane (unknown)
Yarn manufacture:	Unknown
Fabric construction:	Woven
Garment Construction:	Stitched, coated

Material

54% Cotton; 23% acrylic; 23% polyurethane

Measurements

Length: 77cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2018-115

34.

Debenham’s Casual Club swimming costume of polyester and elastane with nylon gusset

See section 3 Elastane; Polyester

Object number

MoDiP: AIBDC 001993

Designer/Maker/Manufacturer/Retailer

Debenhams (retailer)

Production country of the garment and components

Israel

Production date

2001

Description

A size 12 one-piece halter neck swimming costume with 'fish skin' appearance made for Casual Club at Debenhams. The halter neck is joined with a transparent plastic, probably acrylic, side lock. The shimmering effect is achieved by a metalised printed surface made up of small dots in a regular pattern across the entire fabric. The material is chlorine resistant, but the finish is not.

Context

This garment provides a typical example of the use of elastane, also known as Spandex and Lycra®, to give figure hugging stretching properties to a garment.

Labels/Inscriptions

Printed labels inside left side seam: CASUAL CLUB AT DEBENHAMS SIZE 12 EURO 40 87% POLYESTER 13% ELASTANE WASH AS WOOL – RINCE WELL IN CLEAN WATER IMMEDIATELY AFTER USE THIS GARMENT MAY FADE WITH PROLONGED EXPOSURE TO DIRECT SUNLIGHT AND OR CHLORINATED WATER MADE IN ISRAEL 844618821 1064 8200 3182 REF: CCSW.9 DEBENHAM RETAILPLC 1 WELBECK STREET LONDON.

Printed card swing tags attached to halter: CASUAL CLUB SIZE 12 GREEN £26 DEBENHAMS RETAIL PLC 1 WELBECK STREET LONDON LYCRA ONLY BY DUPONT LYCRA I®N SWIMWEAR ADDS: SUPERB FIT, WET OR DRY. LASTING SHAPE RETENTION COMFORT. CHLORINE AND MILDEW RESISTANT (In six languages).

Printed transparent polyethylene label in crotch: HYGIENIC PROTECTION for removal after purchase.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Filament, twisted
Fabric construction:	Knitted
Garment Construction:	Stitched

Material

87% polyester 12% elastane (body); nylon (gusset)

Measurements

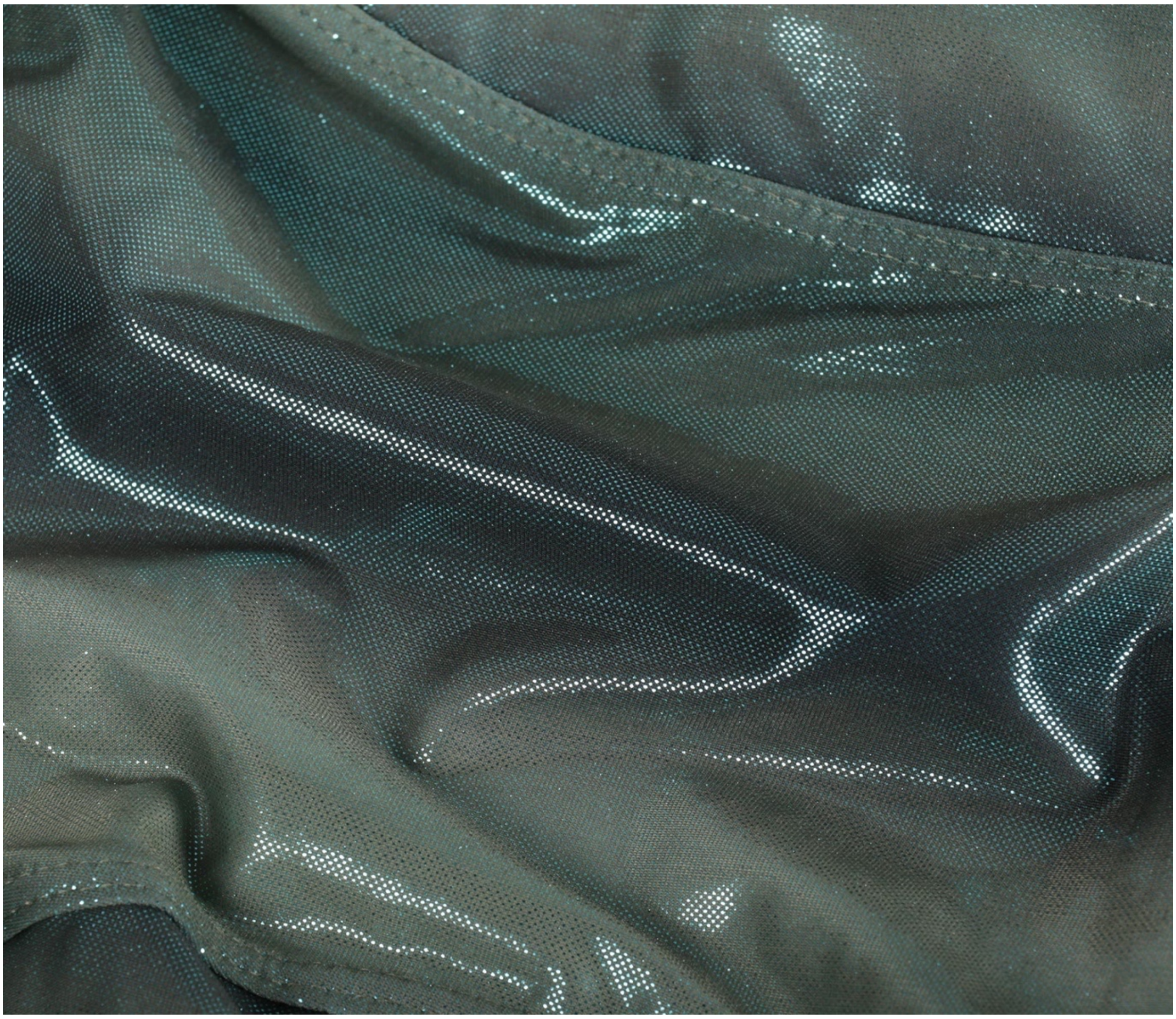
Length centre back: 66cm

Source

Purchase

More information on this object

https://www.modip.ac.uk/artefact/aibdc-001993



35.

Stone Island Spaceman reversible metallic coat of cotton with polyurethane coating and liner of polyester

See section 3 Polyester; Nylon; Polyurethane

Object number

Westminster Menswear Archive: WMA.2016.211.1
Westminster Menswear Archive: WMA.2016.211.2

Designer/Maker/Manufacturer/Retailer

Stone Island (designer); manufactured for Stone Island

Production country of the garment and components

Rumania

Production date

2003

Description

Reversible coat with hood made of dark cream cotton that has been bonded on one side with a silver-coloured polyurethane 'Raso Gommato' coating. The hood has a cream cotton tape threaded through a channel at the front edge that can be tightened by pulling a loop through two holes. The hood has a narrow neck flap around the back to hide the lining rope fastening. It fastens centre front with a metal YKK zip and has two large pockets on each side at waist level. The pockets fasten with black metal press stud fasteners. There are three stitched eyelet holes under each arm for ventilation. The cuffs have one black Stone Island button to fasten the liner. The right sleeve has two black Stone Island buttons to the upper arm to attach a rectangular black and embroidered Stone Island badge. Cuff hems are bound in grey nylon fabric.

Black polyester liner quilted in a large square pattern with polyester wadding interlining. It has a black rib knit round collar and fastens down the centre front with five black Stone Island press stud fasteners. The front opening is edged in wide black webbing, the bottom hem and cuffs are finished with self-binding. There is a mobile phone pocket embroidered in white with the Stone Island emblem to the inside right chest. The liner attaches to the coat around the neck with a black rope tie which is looped through eyelet holes and at each cuff with a button.

Context

Raso gommato is a satin weave cotton of military origin coated in polyurethane. It was introduced by Stone Island in 1984, since when it has been used for a variety of different effects.

Labels/Inscriptions

Coat: Label: Stone Island 0079771 / L / Sportswear Company S.P.A. / SPW Via Confine 2161 / Ravarino (MO) Italia 100% Cotton / Spalmatura [Coating]: Polyurethane / Made in Rumania ART. 39154137/303.

Liner: Label: Stone Island 0079245 / L / Sportswear Company S.P.A. / SPW Via Confine 2161 / Ravarino (MO) Italia Esterno [External]: 100% Polyester Interno [Internal]: 100% Polyester Imbottitura [Filling]: 100% Polyester.

Made in Rumania ART. 39154137/126.

Methods

Fibre manufacture:	Farmed (cotton); extruded (polyester; nylon); unknown (polyurethane)
Yarn manufacture:	Unknown
Fabric construction:	Woven
Garment Construction:	Stitched, bonded

Material

100% cotton (coat); polyurethane (coating); nylon (sleeve edges); 100% polyester (liner)

Measurements

Coat length: 93cm; liner length: 72cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2016-211-1

https://westminster-atom.arkivum.net/2016-211-2

36.

Hwayan Insulated Immersion Suit of Neoprene polychloroprene

See section 3 Polychloroprene

Object number

Westminster Menswear Archive: WMA.2017.036

Designer/Maker/Manufacturer/Retailer

Jiangsu Huayan Marine Equipment Co. Ltd. (manufacturer); Hwayan (registered trademark)

Production country of the garment and components

China

Production date

2007

Description

Red neoprene full-body immersion suit with detachable webbing belt and black plastic clip. It has a hood and wide face flap that fastens from left to right. There is a centre front opening that fastens with a 'KIN' metal and self-sealing waterproof zip that has a large plastic and webbing pull tab. There are two large front patches for the wide black webbing belt to pull through and a wide patch across the back waist. The belt is detachable, fastens with a large metal carabiner clip and loop and has a long black webbing tape 'buddy line' sewn onto the right side. The patches are printed in black, with 'Hwayan' on the right and have a ship's wheel with '0098-14' on the left. At front hip level on the right side is a large black patch pocket with 'Buddy Line inside' printed in white on the front. The left side has the 'Donning Instructions' and illustration printed in black. The feet of the suit are moulded black plastic and are fastened up with black webbing straps. There are integrated mittens with a thumb and two finger shapes. Attached to the back of the neck is a flotation device. On the front chest, upper arms, back and legs are rectangular reflective stickers. There is a large label printed onto the inside back in white with instructions.

Context

Neoprene is a brand name of polychloroprene. It forms an impermeable barrier between the wearer and the elements, providing insulation from environmental condition that would otherwise be uncomfortable or harmful.

Labels/Inscriptions

Printed label inside: INSULATED IMMERSION AND / THERMAL PROTECTIVE SUITS / Model: HYF-2 / This immersion suit is designed to be worn without lifejacket. EC Certificate No. (Module B) 75 982-09HH / EC Certificate No. (Module D) 75 983-09HH / Annex A. 1 Item No. A.1/1.6The characteristic of thermal protection: / After immersion in the circulating calm water at 0-2C for 6 hours, the body temperature will not fall more than 2C below the normal level of the wearer. Manufacture date: 14-7 / Serial No. 14070860 Hwayan 0098-14 / JIANGSU HUAYAN MARINE EQUIPMENT CO. LTD.

Methods

Manufacture:	Melting and baking
Fabric construction:	Sliced and cut to shape
Garment Construction:	Stitched, bonded

Material

Polychloroprene (Trade name: Neoprene)

Measurements

Length: 175cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2017-036


Buddy Line inside


INSULATED IMMERSION AND
THERMAL PROTECTIVE SUITS
The immersion suit is designed
to be worn without lifejacket.
Hwayan
0098-14


MUM HEIGHT -
RANGE - 50
INSTRUCTION
Buddy

37.

North Face fleece jacket partially made from recycled polyester and nylon with some virgin polymer

See section 3 Nylon; Polyester

Object number

MoDiP: AIBDC 006260

Designer/Maker/Manufacturer/Retailer

The North Face (designer and retailer)

Production country of the garment and components

Mexico

Production date

2009

Description

A ‘Denali’ fleece jacket with orange polyester fleece and grey nylon trimmings with front zip, four zipped pockets and underarm zips, made from Polartec Classic300 fleece, containing 87% recycled content made up of 20% post-consumer recycling (PCR), mainly PET bottles, and 80% post-industrial recycling (PIR), mainly yarn scraps. Each jacket, compared with those made with 100% virgin polyester, saves the equivalent of 33lbs of CO^2 and 0.83 gallons of petrol per jacket. The jacket is named after Denali, the highest mountain in Alaska.

Context

The original synthetic fleece was invented in the USA by Malden Mills, now Polartec, in 1979. Fleece mimics many of the finest qualities of wool but is much lighter. The raised pile traps body warmth within its air spaces to provide exceptional warmth without weight. Polyester repels water and the fleece dries quickly.

Polartec Classic300 fleece, introduced in 1989, was originally made from 100% recycled content however by 2009 some virgin polyester was involved. This was because the supply of bottles was unreliable and they could only be made into staple spun fibres, which are not capable of producing such high-performance fabrics as filament fibres, making the fleeces a bit scratchy and the yarns very expensive. Although now each jacket includes some virgin polymer, the use overall of recycled materials is considerably higher. Polartec's sale of 100% recycled fleeces was only about 1% of its annual production. In 2009 its sale of fleeces with the PCR/PIR blend as used in the Denali jacket was 20% of its production. The quality of the product appears to have tipped market interest.

Labels/ Inscription

Machine embroidered logos on chest: Polartec; The North Face.
Woven label sewn into centre top back: The North Face (logo) and another woven label sewn below it: M/M MENS/HOMMES MADE IN MEXICO FABRIQUE AU MEXIQUE.
Woven label sewn into a side seam: POLARTEC® ECO-ENGINEERING™.
Printed on woven labels sewn into a side seam: SHELL A: 100% POLYESTER; SHELL B: 100% NYLON in eight languages and FN# 661661 SEASON# 081 CA#30516 ATYLE# A193 FT 132 THPO# 4500640808. MACHINE WASH SEPARATELY ON DELICATE CYCLE IN WARM WATER. DO NOT USE BLEACH OR SOFTENERS. TUMBLE DRY LOW HEAT OR FOR BEST REULTS, LINE DRY. DO NOT IRON OR DRY CLEAN. SECURE ALL VELCRO CLOSURES (repeated in French).
Printed card swing tag giving details of the minimum amount of savings of trees, gallons of petrol and energy and The North Face Warranty.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Filament, twisted
Fabric construction:	Knitted (polyester); woven (nylon)
Garment Construction:	Stitched

Material

Polyester (orange material); nylon (grey material)

Measurements

Length centre back: 75cm

Source

Gift

More information on this object

https://www.modip.ac.uk/artefact/aibdc-006260

2010s

38.

Aitor Throup X Umbro Archive Research Project Ramsey Jacket of cotton, nylon and elastane

See section 2. 9 Nylon; Elastane

Object number

Westminster Menswear Archive: WMA2018.14

Designer/Maker/Manufacturer/Retailer

Aitor Throup (designer); manufactured for Umbro

Manufacturer

Unknown

Manufactured for

Umbro

Production country of the garment and components

Italy

Production date

2011

Description

Grey jacket with detachable zipped hood and white detailing. It has a white waterproof zip, white taped internal seams and an internal elastic pull across the back. There are two front invisible zip pockets and an internal pocket on the left-hand side with invisible zip. Grey and white striped knitted ribbing has been inserted at the front neckline and front and side waistband. There is a grey knitted ribbing section around the armhole allowing for extra movement alongside two underarm eyelets on the body. It has a three-piece detachable hood with face flap that fastens with press studs, stiff peak and white elastic pull cord.

Context

In 2011 Umbro, in collaboration with Aitor Thorp, following on from their 2009 England Home Kit and 2010 Away Kit, launched the Archive Research Project. For this project Throup reworked seven iconic archive pieces, including the legendary 1966 Ramsey Jacket, inspired by England footballer and manager Sir Alf Ramsey (1920–99), and Aztec football shirt, focusing on ergonomics and anatomy. The research process involved considering what made the original so popular, then designing each item around casts of footballers in a number of poses to look at the points at which articulation was most important.

Labels/Inscriptions

EUR/USA.

Internal Label: Body: 51% cotton 44% nylon 5% elastane. Rib: 100% cotton. Umbro/Aitor Throup Archive Research Project. Factory code 2222. Made in Italy. RN109787-CA-07820.

Methods

Fibre manufacture:	Farmed (cotton); extruded (nylon; elastane)
Yarn manufacture:	Spun
Fabric construction:	Woven (body), knitted (rib)
Garment Construction:	Stitched, taped

Material

51% Cotton, 44% nylon 5% elastane (body); 100% cotton (rib)

Measurements

Length: 69cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2018-14

39.

Protective undershirt of modal, aramid, elastane and carbon fibre

See section 3 Aramid; Elastane; Modal; Viscose rayon

Object number

MoDiP: AIBDC 007097

Designer/Maker/Manufacturer/Retailer

Sparco S.p.A. (designer and retailer)

Production country of the garment and components

Italy

Production date

2015

Description

An undershirt designed as protective clothing for racing car drivers, intended to protect the wearer from heat and flames for a limited period, conforming to regulatory standards of safety. The shirt has a high neck; the body is of circular knitted construction with feature seams in grey thread. The shirt has been chemically treated with x-Cool Silver treatment which provides 'an efficient reduction in body temperature and a cooling sensation enriched with an innovative anti-bacterial treatment'. Under the terms of the warranty wearers are advised that the materials are light sensitive and should not be exposed to direct light sources or sunlight for excessive periods of time. A warning is given that light may cause colour changes and start the aging process of the material. It is likely that the 1% carbon fibre relates to the thread used for the stitching.

Context

Sparco is a company dedicated to giving motorsport more safety and more style. Fire resistance is provided by the aramid, known also as Nomex® and Kevlar, which has a very high melting point and low flammability. It is a difficult material to work and will have been blended with polynosic rayon (modal viscose) to facilitate its use. Polynosic rayon is a high strength rayon fibre that makes a luxurious fabric, cool to the touch, absorbent, and similar in texture to silk or cotton. Carbon fibre is stronger than steel. Its fibres can be thinner than human hair and only burn at extreme temperatures.

Labels/Inscriptions

Printed centre front on high neck: sparco; lower left front: X-COOL SILVER.

Woven label sewn to outside back of shirt: In compliance with F.I.A standards 8856.2000 sparco™.

Printed label sewn into hem: sparco SIZE M/L 69% Modal Viscose. 28% Aramid 1% Carbon Fibre. 2% Elastane. Designed and Manufactured in ITALY. With care graphics indicating it can be washed at 30 degrees but not dry cleaned.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Filament, twisted
Fabric construction:	Knitted
Garment Construction:	Stitched

Material

Polynosic viscose rayon 69% (Modal viscose); aramid 28%; elastane 2%; carbon fibre 1%

Measurements

Length centre back: 70cm

Source

Purchase

More information on this object

https://www.modip.ac.uk/artefact/aibdc-007097

40.

Salvatore Ferragamo shirt and skirt of woven Orange Fiber viscose and silk

See section 3 Orange fiber viscose; Viscose rayon

Object number

V&A: T.1710:1, 2-2017

Designer/Maker/Manufacturer/Retailer

Salvatore Ferragamo S.p.A. (designer, manufacturer and retailer; print designed by Mario Trimarchi)

Production country of the garment and components

Italy (garments designed and constructed)
Spain (yarn spun), Italy (textile woven)

Production date

2017

Description

An outfit comprising a shirt and skirt of silk and Orange Fiber twill printed with a pattern in black and white. The fabric is fine and lightweight and feels and behaves much like pure silk. Orange fiber is a type of viscose rayon.

Context

This outfit is from a capsule collection released by Ferragamo on 22 April 2017 to coincide with Earth Day. The collection was the first example of commercially available garments made from Orange Fiber. Ferragamo chose to launch the Orange Fiber capsule collection on Earth Day to highlight the reduced environmental impact of the fibre in comparison with conventional fibres: Orange Fiber utilises a waste material (citrus skins) and repurposes it. It can be made in a closed-loop system.

Labels/Inscriptions

SALVATORE FERRAGAMO. MADE WITH ORANGE FIBER. EXTERNAL FABRIC: 67% CELLULOSIC FIBRE/ 33% SILK. MADE IN ITALY.

Methods

Fibre manufacture:	Extruded
Yarn manufacture:	Twisted
Fabric construction:	Woven (silk warp, Orange Fiber weft)
Garment Construction:	Stitched

Material

67% Orange Fiber (cellulosic fibre), 33% silk

Measurements

Width: 48cm

Source

Given by Salvatore Ferragamo S. p. A.

More information on this object

https://collections.vam.ac.uk/item/O1407615/skirt-salvatore-ferragamo-spa/

41.

RubyMoon Rash Guard top of Econyl® nylon and Lycra® Xtra Life™ elastane

See section 3 Elastane; Nylon

Object number

MoDiP AIBDC: 008185

Designer/Maker/Manufacturer/Retailer

RubyMoon (designer of garment and manufacturer); Arnett, Sarah (designer of print)

Production country of the garment and components

Spain

Production date

circa 2018

Description

A long sleeved, high-necked, stretchy top designed to be worn in the water, as a cover up out of the water, and at the gym. The top bears a decorative print entitled Tropical Verve on a blue and black background. It has a short zip at the back up to its high neck. The material is 78% recycled polyamide (Econyl®) and 22% polyurethane (Lycra® Xtra life™).

Context

This garment is part of the RubyMoon Gym to Swim® collection which aims to tackle plastics pollution and focuses on the look, construction and fit to create the best fitness wear possible using chlorine resistant, durable, high quality fabric.

The recycled polyamide is a material called Econyl® which is made from used fishing nets and other regenerated material. RubyMoon is a partner of Healthy Seas (healthyseas.org) which collects drifting or 'ghost' nets and ensures they become a valuable resource. The fabrics use waste-reducing printing and dyeing techniques and are certified Oekotex and vegan meaning no harmful chemicals are used.

Labels/Inscriptions

Printed on woven labels, sewn inside right hip: RUBYMOON 78%nylon / polyamide/ polyamid 22% elastanne / elastane Trim excluded. Made in Spain and with washing instructions.

Method

Fibre manufacture: Extruded
Thread manufacture: Spun
Fabric construction: Knitted
Garment construction: Stitched

Material

78% Nylon / polyamide/PA (regenerated) (Trade name: Econyl®)
22% Elastane; (Trade name: Lycra® Xtra Life™)

Measurements

Length centre back: 59 cm

Source

Purchase

More information on this object

https://www.modip.ac.uk/artefact/aibdc-008185




42

Vollebak Graphene Jacket, one side of graphene coated polyurethane, the other of a nylon and elastane blend

See section 3 Polyurethane; Nylon; Elastane

Object number

Westminster Menswear Archive: WMA.2019.109

Designer/Maker/Manufacturer/Retailer

Vollebak (designer); manufactured for Vollebak

Production country of the garment and components

Portugal

Production date

2019

Description

Fully reversible jacket with hood and two-way waterproof YKK zip closure at centre front. All panels are laser-cut, bonded and the seams are sealed. The jacket has two laser-cut reversible front pockets and a peaked hood with elasticated drawcord hem edge. There is an adjustable drawcord at the waist and the sleeve shape has been designed with extra underarm panelling for articulation. There are welded eyelets under the arms. The cuffs are laser-cut and bonded. Taped seams. Size M. One side of the jacket is made of polyurethane coated with graphene. If this is worn next to the body it will help equalize skin temperature by sending heat from the hotter bits of the body to the colder. It will also increase body temperature by 2 degrees centigrade. The other side is of high strength and high stretch nylon. If worn next to the body, it converts the jacket into a lightweight running jacket.

Context

Technical characteristics: Fabric is heat conductive and heat retaining. Waterproof to 10,000mm. Breathability rating: RET 12 (very breathable). Graphene is the world's thinnest material. It is bacteriostatic, anti-static, certified non-toxic and hypoallergenic. Windproof. Four way stretch to the fabric.

Labels/Inscriptions

Printed onto grey Graphene side: VOLLEBAK / GRAPHENE JACKET / MADE IN PORTUGAL / M / The inside of the jacket is constructed from a water-resistant Graphene membrane combined with polyurethane. The jacket's outer face is built from 85% Polyamide and 15% elastane.

Methods

Fibre manufacture:	Extruded (nylon; elastane); unknown (graphene; polyurethane)
Yarn manufacture:	Spun (nylon; elastane); unknown (graphene; polyurethane)
Fabric construction:	Woven (nylon; elastane); unknown (grapheme; polyurethane)
Garment Construction:	Bonded

Material

Graphene coated polyurethane (inner); 85% nylon (polyamide) and15% elastane (outer)

Measurements

Length: 78cm

Source

Purchase

More information on this object

https://westminster-atom.arkivum.net/2019-109-2

2020s

43.

Purotatto top of MicroModal regenerated cellulose and casein fibre

See section 3 Casein fibre; Viscose rayon

Object number

MoDiP: AIBDC: 009064

Designer/Maker/Manufacturer/Retailer

Sabintima SRL [designer and manufacturer for their brand Purotatto]

Production country of the garment and components

Italy

Production date

circa 2021

Description

A blush pink long sleeved, roll neck top. 'PUROTATTO MADE IN ITALY' is printed centrally on the inside back panel below the neck seam. The material is 60% MicroModal and 40% casein fibre.

Context

This top was part of Purotatto's A/W 2021 womenswear collection. Its retail price was £99.00. On an attached paper swing tag, shaped like a milk bottle, the company promoted the sensory qualities of milk protein fabric and by implication its luxuriousness. 'Like Milk on the Skin. This garment is made of a milk protein fabric. It is lightweight, soft and smooth like silk. This transpiring fabric makes the garment as comfortable as a second skin'. The milk fibre is blended with MicroModal which has similar qualities but is more resistant to shrinking. It is a very fine, soft, High Wet Modulus fibre. Contrary to the information printed on the label in the side seam, the same chemicals that are used to produce viscose rayon are also used in the manufacture of MicroModal. However, MicroModal is currently only produced by Lenzing AG in factories in the European Union using wood pulp from sustainably managed plantations. It is made in a closed loop process. The production process employed to create milk fibre protein is more obscure. The Purotatto website states that its manufacture involves dehydrated milk and bioengineering.

Labels/Inscriptions

Printed on woven labels sewn into a side seam:

Label 1: 42/purotatto.com/MADE IN ITALY/This garment is the result of a careful selection of very finest natural threads, and has undergone no chemical treatment. We recommend you take the same care when washing it, following the instructions on the label. Produced and distributed by Sabintima Srl.' This text is repeated in Italian.

Label 2: 60% MICROMODAL/ 40% FIBRA DI LATTE MILK FIB

Letters applied to fabric inside back neck: PUROTATTO MADE IN ITALY.

Methods

Fibre manufacture:	Extruded
Thread manufacture:	Spun
Fabric construction:	Knitted
Garment construction:	Stitched

Material

60% Lyocell (MicroModal)

40% Milk protein fibre

Measurements

Length at centre back from nape of neck: 600mm

Source

Gift

Link to the owning museum's documentation

https://www.modip.ac.uk/artefact/aibdc-009064

6. Potential narratives and research areas

Each entry for the Featured Fibres and Materials in section 2 includes suggestions for potential narratives and research. Many are applicable beyond the featured fibre that they are associated with in the text. In this section the narratives and suggestions for further research have been arranged by theme and offer a different way of accessing them. It is important to remember that manufacturing textiles from natural fibres also has disadvantages and dangers as well as benefits.

6.1 Historical drivers behind the development of synthetic fibres

- not subject to the effects of seasonality, crop failure, disease, the fluctuating cost of expensive raw materials such as silk or interrupted supply chains.
- once the fibres are commercially viable, they are usually less expensive than natural materials.
- offered a means of developing a new industry to reduce unemployment, as for example the viscose rayon industry established in Norway in the 1930s; or, in the case of a company, Courtaulds, to manufacture a new product range to replace a material for which demand had stalled.
- not affected by moth and other pests: easier to warehouse.

6.2 Possible environmental impacts of the manufacture and use of synthetic fabrics

- occupational health hazards caused by exposure to chemicals and industrial accidents.
- emission of toxic fumes which can lead to land, air and water pollution, resulting in health risks for those living in the vicinity of production sites and within range of their chimneys, as well as those living downstream from affected waterways.
- water pollution can poison drinking water supplies and kill fish stock; land pollution can destroy ecosystems, affecting domestic animals, flora and fauna.
- their manufacture can pose a fire risk.
- microplastics shed during domestic washing, which are harmful to species including humans.

6.3 Animal welfare

- substitutes for silk, leather, fur and wool.
- synthetic fibres are marketed as animal-friendly and suitable for vegans, but it is important to remember that their production can pollute the land, air and water upon which animals depend.
- comparative impact of synthetic (man-made) textiles and textiles derived from plants and animals.

6.4 Contribution to fashion

- reduction in cost of fashion.
- introduction of new materials with properties and qualities, especially textural, that are not found in fabrics made from traditional materials, for example PVC.
- blending natural and synthetic fibres has many benefits in terms of cost and performance.
- finishing agents made from synthetics can improve the performance and care of natural materials, for instance making woollen garments machine washable.

- synthetics such as elastane have revolutionised the comfort and performance of close-fitting clothes such as underwear and sportswear.

6.5 Contribution to technical textiles for specialist situations

- warfare.
- protection in extreme heat and cold.
- space travel.

6.6 Contribution to a democratic world

- generally low cost.
- easy care: wash and wear, quick drying, non-iron.
- hardwearing and not affected by moth and other pests.
- mimicry of luxury materials.

6.7 Contribution to climate change

- fully synthetic fibres are made from non-renewable resources; their manufacture can be very energy intensive from the extraction and transportation of the oil and gas from which they are made to their manufacture; this in turn increases greenhouse gas emissions.
- pollution generated by their manufacture can harm delicate ecosystems, on land and in the sea and other waterways, whose damage impacts on the flora and fauna that depend on them.
- many synthetic fibres are not biodegradable; recycling is not always an option; disposal by incineration and landfill can lead to more pollution and emissions.

6.8 Contribution to sustainability

- some semi-synthetic fibres can be produced in closed loop systems designed to reduce or eliminate toxins and reduce water use and wastage.
- some synthetics, for instance polyester, are very durable and have the potential to be recycled both as garments and fabric as well as being recycled to create new fibres.
- some semi-synthetics, for instance those made with cotton linters, and regenerated protein fibres, utilise a waste product.
- a new generation of bio-based synthetics is the subject of global research, development and investment.

7. Glossaries

7.1 Glossary of general terms

Azlon

Manufactured fibres made from any regenerated naturally occurring protein.

Bio-based fibres

Fibres based on naturally occurring polymers produced by living organisms such as cellulose, starch and sugar.

Biodegradable

Biodegradable materials are materials that can be broken down naturally in the right conditions by enzymes produced by living organisms.

Blending

The process of combining two or more different fibres to form a composite yarn, and of combining different yarns within the structure of a woven fabric, in both cases to take advantage of their differing qualities.

Bonded fabrics

A nonwoven fabric in which the fibres are held together by a bonding material. This may be an adhesive or a bonding fibre with a low melting point.

Carded fibres

Raw or washed fibres that have undergone a process of brushing to thin them out and evenly distribute them to facilitate spinning.

Cellulose

Carbohydrate substance derived from plants, contained in all vegetable fibres and semi-synthetic fibres, such as acetate, cuprammonium, viscose rayons and Tencel.

Chemical Recycling

Chemical recycling uses chemical processes to convert waste semi- and fully synthetic fabrics, and blends of the same, such as cotton and polyester, into new fibres. These fibres are in turn often blended with virgin fibres to improve their performance. Although limited commercial production of some types of recycled fibres is possible, chemical recycling on a large scale is not. It is however the subject of global research and development. (See: Recycling.)

Closed loop processing

Methods of capturing and reprocessing solvents used in the manufacture of semi- and fully synthetic fibres.

Coatings

A textile coating impregnates the base cloth with a resin or other substance, to create a new textile structure the properties of which depend on the qualities of both its components.

Composting (domestic and industrial)

Composting depends on managed processes of decomposition, whether these are carried out in a domestic or industrial context. Industrial composting systems are designed to process large volumes of municipal and commercial waste, and other waste which requires the systematic control of temperature, moisture and air flow to successfully biodegrade. Home composting takes place at a lower temperature and over a longer time.

Drawing

Drawing synthetic filament fibres: the process of stretching and strengthening manufactured filaments, usually carried out shortly after the extrusion process.

Drawing staple fibres: the process of running multiple slivers through a series of rollers to combine and straighten the fibres, achieving greater yarn uniformity, strength, and lustre.

Enzymes

Proteins with specific structures that act as catalysts (accelerate chemical reactions) for a wide range of natural processes, one being polymerisation.

Extrusion

The process of forcing viscous liquid (i.e., molten or dissolved polymer) through holes in a spinneret to create a continuous filament.

Fibre

A long thin, flexible structure, that may either be extruded in a continuous length or spun to create such a continuous flexible structure.

Filament fibre

A fibre of extreme, continuous length. Filament yarn is made from one or more filament fibres combined and is usually of a fine, smooth texture that creates a high lustre.

Finishes

Chemical treatments applied to fabric to give a specialist finish, such as anti-wrinkle and fire-retardant finishes.

Fossil fuels

Materials, such as coal, oil, and natural gas, containing carbon, formed by geological processes acting on the remains of organic matter produced by photosynthesis, a process that began over 2.5 billion years ago.

FTIR spectroscopy

A means of identifying from what fibres are made. The fibres are subjected to infrared radiation. Some of the radiation is absorbed and some of it is passed through (transmitted). The resulting spectrum (graph) represents the molecular absorption and transmission, creating a molecular fingerprint of the sample fibre.

Gore-Tex

Gore-Tex is a thin, flexible, waterproof, breathable membrane of polytetrafluoroethylene (PTFE) containing minute holes. The Gore-Tex website claims each square inch has nine billion pores. Each of these tiny holes is 20,000 times smaller than a water droplet. This is what makes the membrane waterproof. A related well-known brand name of a PTFE-based composition is Teflon.

Hygroscopic

Of a material that tends to absorb water from the air.

Hydrophobic

Of a fabric that tends to repel water.

Linters

Very short fibres of cotton remaining on the cotton seed after the seeds have been separated from the cotton fibre in the gin. The fibres are too short for spinning but removed from the seeds, they can be used as a source of cellulose.

Lurex

Lurex is a yarn made from a thin strip of aluminium sandwiched between two plastic films invented in 1946. The most often used plastics for the films are polyester and nylon. It is lighter weight than lamé, does not tarnish, and is strong enough to be used in power looms to make complex woven fabrics, making new metallic fabrics possible.

Mechanical recycling

Mechanical recycling has been used to recycle textile waste since the early nineteenth century. It uses mechanical processes to break down textiles into a form in which they can be reutilised. (See: Recycling.)

Microfibres (plastic)
Plastic microfibres are tiny pieces of microplastics released when we wear and wash synthetic clothing. They are so small that many pass through filtration processes and make their way into rivers and seas damaging the eco system.

Pill or Pilling
Small balls of fluffy or felted matter on the outer surfaces of woollen and wool-like knitted and woven garments, caused by repeated rubbing together of fabric surfaces during wear.

Polymers
Repeated groups of atoms held together by strong chemical bonds. All plastics / synthetic fibres are polymers, but not all polymers are plastics.

Polymerisation
Any chemical process (natural or caused by man) in which monomers are joined to create longer polymer chains.

Protein fibres
Animal hair, wool, or silk.

Recycling
Recycling converts discarded materials or products into new items by re-purposing them. Down cycling is a branch of recycling that converts textiles, such as blended fabrics which are currently difficult to recycle at scale, into items of lower value than the source material, for instance insulation. Upcycling is a form of recycling that converts the source material into an item of higher value, such as repurposing scraps from the factory floor into small accessories. (See: Chemical recycling and Mechanical recycling.)

Regenerated fibres
Fibres made from cellulose-based fibres that originate from plants such as wood pulp. They are described as regenerated because of the chemical process used to create the fibre, making them part natural and part artificial. Viscose, cuprammonium and acetate rayons are examples of regenerated fibres.

Regenerated protein fibres
Man-made fibres produced from either animal or vegetable non-fibrous proteins which have been reconfigured to take up a fibrous form to emulate the natural protein fibres wool and silk. They are sometimes called Azlons.

Semi-synthetic fibres
Part natural and part synthetic fibres made from chemically treated cellulose and protein derivatives.

Sliver
A long, thick strand of multiple untwisted, but usually carded, fibres.

Spinneret
A nozzle or plate, usually metal, with tiny holes, through which a viscous liquid such as one containing viscose is forced to produce continuous filaments.

Spinning
The act or process of converting staple or short lengths of fibre into continuous yarn. Also the extrusion of a solution of fibre forming substances through holes in a spinneret to form filaments.

Staple fibre
A fibre of shorter, or non-continuous length (as opposed to filament fibres) that requires spinning and twisting together to create yarn lengths.

Sustainability
Sustainability refers to a state in which the economic, social and environmental spheres are aligned and maintained in an equitable and harmonious balance which can endure over the long term, enabling current and future generations to meet their needs. More precise meanings of sustainability depend on the context and field. In the case of the textile and fashion industry assessing whether a process or product is sustainable is problematic and difficult to measure because of the opacity and complexity of the global fashion system.

Synthetic fibres
Man-made fibres derived from fossil fuels and produced by chemical polymerisation, which may be manufactured in filament or staple yarns.

Tyvek®
Tyvek® is a nonwoven material manufactured by Dupont. Polyethylene fibres are spun, entangled, and then heat and pressure bonded. It is lightweight and durable; breathable, yet resistant to water, abrasion, bacterial penetration and aging. It is widely used for protective garments.

Vegetable fibres
Fibres made from plants, for example cotton, flax, jute and hemp.

Warp
The collection of continuous threads that make up the length of the cloth, through which the weft thread is passed to make the fabric.

Weft
The crosswise thread that is passed over and under the warp threads from selvedge to selvedge to make cloth.

Wicking
The process of evaporating away moisture and perspiration.

Yarn
The continuous thread or strand of textile fibre, either endless filaments or shorter fibres spun together, or a combination of the two, that are woven, knitted, crocheted, braided or otherwise utilised to create a textile.

Zeins
Regenerated fibres made from corn.

7.2 Glossary of chemical terms
Glossary entries are cross-referenced in **bold**.

Acid
Any water-soluble substance giving solutions of low **pH**, such as sulphuric acid.

Alkali
Any water-soluble substance giving solutions of high **pH**, such as sodium hydroxide.

Aromatic
A type of **organic** compound containing **atoms** arranged in a stable ring system. A simple example is benzene, the **molecule** of which is a ring of six carbon atoms each with one hydrogen atom attached.

Aqueous
In or containing water, e.g. an aqueous solution is one in which the substance is dissolved in water.

Atom
The smallest subunit of matter. Subatomic particles, electrons, protons and neutrons, are the building blocks of atoms and they give rise to 118 varieties. These are known as elements e.g. oxygen, carbon, iron, etc.

Carbohydrate

An organic compound where the hydrogen and oxygen **atoms** are in the ratio 2:1 respectively (i.e. H_2O). Examples are **cellulose**, starch, and sugars such as sucrose, glucose and fructose.

Cellulose

An insoluble substance which is the main constituent of plant cell walls and of vegetable fibres such as cotton. It is a **polysaccharide** consisting of chains of glucose **molecules**, end to end.

Copolymer

A **polymer** comprising subunits of different types joined together. Copolymerisation is the process for making copolymers.

Dechlorination

The process of treating a substance to remove all or some of the chlorine atoms.

Diol

An **organic** compound containing two hydroxyl groups per molecule (not attached to an **aromatic** ring).

Dispersion

Very small particles (in this context **polymer** particles) dispersed in water, sometimes called an emulsion or a latex, usually manufactured via **polymerisation** of a dispersion of monomer in water (emulsion polymerisation).

Grafted

In the context of **polymers**, this means joined with a strong chemical bond.

Hydroxyl group

A hydrogen **atom** bonded to an oxygen atom. Hydroxyl groups typify alcohols or phenols.

Hydrolysis

Any decomposition **reaction** which is caused by water. **Acids** or **alkalis** are usually involved and hasten such a reaction. For example the acetate groups of poly(vinyl acetate) can be removed by '**hydrolysis**' with water and sodium hydroxide to form poly(vinyl alcohol) and sodium acetate.

Macroglycol

A **diol** of much increased molecular chain length.

Membrane

A very thin film, usually composed of a **polymer**. Gore-Tex **membrane** is a porous film of polytetrafluoroethylene approximately 0.01mm thick.

Molecule

A group of **atoms** of fixed number and position constituting the smallest unit defining a substance. For a more detailed explanation see the section Fibres in focus /Simple polymer chemistry.

The process of heating until decomposition occurs.

Reaction (chemical)

Changing of a substance at the molecular level. **Hydrolysis** and **polymerisation** are examples of chemical reactions.

Semi-synthetic

Describes products which are man-made using naturally occurring starting materials.

Synthetic

Describes products which are completely man-made (synthesised).

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9. Methodology and contributors

This resource was made possible by an Art Fund Curatorial Network Grant with additional support from the British Plastics Federation, Worshipful Company of Horners, and Plastics Historical Society.

It is the result of collaboration between the Dress and Textiles Specialists (DATS) led from the Victoria and Albert Museum (V&A) with Glasgow Museums; and the Plastics Subject Specialist Network (PSSN) led from the Museum of Design in Plastics (MoDiP).

Project team members were Connie Karol Burks, textile expert, and Stephanie Wood, textile expert and project manager, both V&A; Edwina Ehrman, dress historian, and former curator at the V&A and Museum of London; Rebecca Quinton, textile expert and DATS chair, Glasgow Museums; Professor Susan Lambert, PSSN convenor and project leader, MoDiP, Arts University Bournemouth; Dr Anita Quye, plastics and textile expert, University of Glasgow's Archives and Special Collections; Dr Leanne Tonkin, plastics and textile expert and conservator, Nottingham Trent University.

The content and structure of the resource was agreed by the project team. Then, using a model of participatory research, knowledge was pooled and discussed at five specialist workshops held at the V&A, MoDiP, Leeds Museums and Galleries, Westminster Menswear Archive and the University of Glasgow's Archives and Special Collections. Each workshop studied a range of objects from the venue collection. Thus, the V&A workshop focused on high fashion; MoDiP's on more everyday garments; Leeds on tailoring; Westminster Menswear Archive's on menswear and specialist clothing; and the University of Glasgow's Archives and Special Collections on information gleaned from archival sources.

The workshops were attended in person and online. Attendees in addition to the project team included Emma Bowron, Oriole Cullen, Dr Louise Dennis, Joana T. Ferreira, Vanessa Jones, Pamela Langdown, Jannicke Langfeldt, Dr Susan Mossman, Katherine Pell, Natalie Raw who led the Leeds Museums and Galleries workshop, Alison Spence, Dr Daniel Sprecher who led the Westminster Menswear Archive workshop, Sonnet Stanfill and Dr Lucie Whitmore. Their insights and ongoing support for the project were invaluable.

Building on the knowledge shared at the workshops and imparted in project team meetings, the guide, through an iterative process, was compiled by Susan Lambert, edited by Edwina Ehrman, and copy-edited and formatted by Rebecca Quinton. Texts were contributed by Connie Karol Burks, Edwina Ehrman, Dr Brenda Keneghan, Dr James Massy, Dr Anita Quye, Natalie Raw, Dr Danielle Sprecher, and Dr Leanne Tonkin. The scientific facts were checked by Dr Brenda Keneghan.

Fibre samples were taken by Nora Brockmann at the V&A, Emma Bowron at Leeds Museums and Galleries, and Lizzie Cherry of Janie Lightfoot Textiles at Westminster Menswear Archive and MoDiP. Their analysis was undertaken by Louise Garner, PhD student, working to Dr Katherine Curran, Institute for Sustainability, University College London. Lucia Burgio from the V&A also provided support.

Photography was undertaken by David Lindsay at Leeds Museums and Galleries; photographs of MoDiP objects are courtesy of MoDiP, Arts University Bournemouth; of WMA objects courtesy of Westminster Menswear Archive, University of Westminster; and of V&A objects courtesy of the Victoria and Albert Museum.

The resource has been peer-reviewed by users at a workshop held at the Museum of London led by Dr Lucie Whitmore. Further peer-review workshops supported by the Dress and Textile Specialists (DATS) in collaboration with the Plastics Subject Specialist Network (PSSN) are planned

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