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Professor of Polymer Technology and
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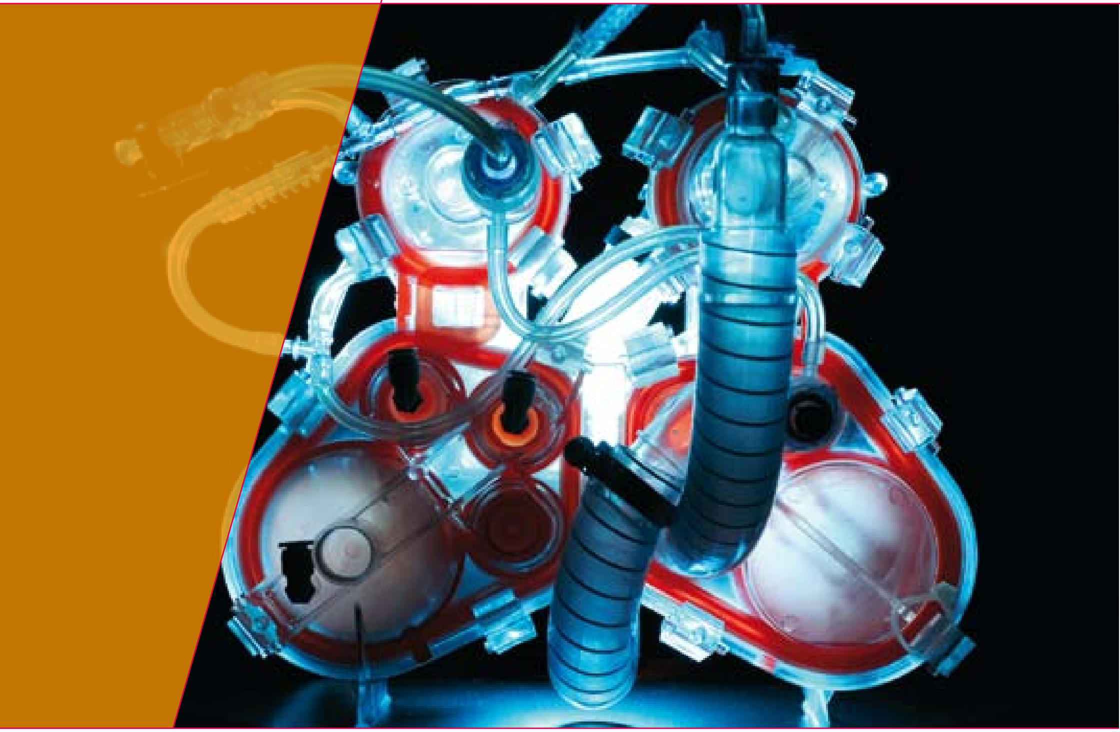
Han Meijer is full professor of Polymer Technology and scientific director of Eindhoven Polymer Laboratories (EPL). Born and educated in Amsterdam, he went on to obtain his PhD from the University of Twente in 1980. He then joined DSM Research and, in 1985, was appointed part-time professor at the department of Polymer Chemistry and Technology of the TU/e in the field of applied rheology. Since 1989, he has been full professor of polymer technology at the department of Mechanical Engineering. His present interests include structure development during flow and structure-property relations, micro-rheology and microfluidics, micro-macro-mechanics, modeling of polymer processing, and design in polymers. And the America's Cup yacht race.

Polymers@TU/e

Without a doubt, polymer science and technology has increased almost exponentially at the TU/e campus over the past decade. The various polymer groups, spread over different departments, have found each other and cooperate in truly multidisciplinary projects that are coordinated, when necessary, by the local research school Eindhoven Polymer Laboratories (EPL).

Polymers have a low density, ease of processing and shaping, possibilities of functional integration, and an almost unlimited flexibility in molecular design. Moreover, polymers are generally relatively cheap, which makes them very different from most other materials we use to shape our world. These characteristics make polymers very useful for protection, insulation, transportation, communication, illumination, packaging, housing, furniture, clothing etc. There is a great demand for improved polymer systems in these application areas. This sets the focus for scientific research at EPL and elsewhere.



We recently redefined the focal points of research as follows:

1. Complex molecular systems;
2. Functional polymers and devices;
3. Multi-scale modeling and advanced characterization.

The first area seeks to establish how complex molecular systems form by self-organization and function, partly mimicking nature and life. The second area investigates how useful advanced devices can be made out of complex, usually functional, polymers. The third area addresses questions concerning our understanding of polymers and polymer systems.

Dutch Polymer Institute

The Dutch Polymer Institute (DPI) supports our research in Eindhoven with roughly 50% of its budget. The DPI is a public-private organization with a mission to stimulate university research with industrial relevance. It has defined a possible fourth area of focus, namely materials design and engineering. This reflects the industrial need to design and engineer new polymer materials, partly based on bio-based renewable resources.

Naturally, many research projects cross the boundaries between these areas of focus. Good cooperation with other disciplines is guaranteed by cross-appointments of various key experts in these fields.

We currently have 210 researchers at EPL, comprising 45 tenured staff, who direct temporary staff including 45 post-docs and 120 PhD students. Over the past seven years, the period in which EPL was officially recognized by The Royal Netherlands Academy of Arts and Sciences (KNAW), we produced 189 dissertations and 1,949 publications, with the aid of external funding of EUR 62.6 million in total. This amounts to an average of 27 dissertations and 280 publications a year. Our annual external funding of EUR 9 million is provided by the National Science Foundation NWO (30%), the Dutch Ministry of Economic Affairs (30%), industry (15%), and the European Community (10%). The remaining 15% is covered by matching funds from the university.

TU/e boasts a phenomenal and unrivaled range of polymer research. Moreover, the quality of research is well above average, with all EPL groups achieving excellent scores in successive international research assessments. Our work has far-reaching impact and is extensively cited in scientific publications.

Disposable bioreactor

The standard of some of our research is exemplified by the disposable bioreactor that we designed and realized in cooperation with the department of Biomedical Engineering. Tissue engineering of autologous heart valves is based on a patient’s own stem cells, taken from his or her bone marrow. This research work is carried out by Frank Baaijens’ group at the department of Biomedical Engineering.

To specialize the cells into a heart muscle, mechanical stimulation is required during formation and growth. Patient-specific heart valves take about four weeks to grow on a biodegradable polymer. During that period, the growing cells gradually adopt the shape and function of the polymer.

If the development of this tissue engineering is going to be successful,

the process has to be scaled up dramatically. Worldwide, about 250.000 valve transplantations are performed every year. Per patient, three valves must be grown, the best of which are implanted. That means there is clearly a need for flexible, integrated, cheap and disposable bioreactors.
We have realized a design that exploits the capability to mold two components into a single product, combining rigid and soft polymers. The rigid polymer forms the body of the reactor, in which a scaffold is placed and to which tubing is connected. The soft polymer constitutes the flexible membranes and steering valves that control the fluid during fabrication and testing of the heart valves. This is done under non-fouling, non-contaminating, sterile conditions.

Microfluidic reactor

As a sequel to this bioreactor, we have designed a microfluidics reactor. In this project, we have combined hard and soft polymers on a smaller scale, allowing for miniaturization while maintaining integration and function.
A microfluidic reactor not only requires channels through which fluids flow, but also a well-defined mixing operation. Mixing is important for fast heating and cooling, for controlled start of a reaction by adding components, but also for reaction quenching, for example by washing.
Reynolds numbers are low and Péclet numbers are high in small channels, so mixing is realized through chaotic advection. This means the Baker's transformation is the preferable way to go. We have designed and realized a splitting and recombining serpentine micromixer that almost perfectly mimics this transformation.
This opens routes to control the start of reactions, but also the sequencing.
Moreover, miniaturization allows the integration of multiple reactors in a single device. In the prototype design, we can combine up to five different fluids that are pumped using the peristaltic motion of a sequence of flexible steering valves, actuated by a number of tiny linear motors. The first goal is the precise step-by-step synthesis of oligomers like peptides. This will be realized in the near future in the Institute of Complex Molecular Systems (ICMS) headed by professor Bert Meijer.