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Research Article

Latent Fingerprint Enhancement Using Tripolyphosphate-Chitosan Microparticles

Issa M. A. Il Dueik and Gordon A. Morris

Department of Chemical and Biological Sciences, School of Applied Sciences, University of Huddersfield, Queensgate, Huddersfield, West Yorkshire HD1 3DH, UK

Correspondence should be addressed to Gordon A. Morris; g.morris@hud.ac.uk

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Chitosan has been widely used in the preparation of microparticles for drug delivery; however, it has not been considered in forensic applications. Tripolyphosphate- (TPP-) chitosan microparticles were formed using ionotropic gelation in the presence of a coloured dye and deposited onto latent fingerprints enabling fingerprint identification.

1. Introduction

Chitosan is the generic name for a family of strongly polycationic derivatives of poly-N-acetyl-D-glucosamine (chitin) extracted from the shells of crustaceans or from the mycelia of fungi [1]. In chitosan the N-acetyl group is replaced either fully or partially by NH_2, and therefore the degree of acetylation can vary from DA = 0 (fully deacetylated) to DA = 1 (fully acetylated, i.e., chitin). The long carbon chains of chitosan molecules render them lipophilic. Furthermore, chitosan is the second most abundant polymer on earth (after cellulose) and it is the only known naturally occurring polycationic polysaccharide; therefore, chitosan and its derivatives, including microparticles, have received a great deal of attention from the food, cosmetic, and pharmaceutical industries [2–4]. Microparticles can be prepared by the electrostatic interaction and the resultant ionotropic gelation between chitosan and the tripolyphosphate (TPP) (Figure 1) polyanion [2–4]. Size can be controlled by varying the chitosan : TPP ratio, pH, and the molar mass of the chitosan.

Fingerprint detection is probably the oldest and most common method of identification used in forensic science. Fingerprints, therefore, present a perfect method for personal recognition; they are traces of an impression from the friction ridges on a person's fingertips. Fingerprinting is used in the tracking and identification of criminals, and because they are unique (identical twins have different fingerprints), fingerprints can provide a clear and positive proof of identity.

Recently, there has been great interest in the use of nanotechnology in the design of novel fingerprint detection systems. This is due to the fact that microparticles can provide improved latent fingerprint detection by using dye-functionalized microparticles (the dye or fluorophore may also be encapsulated within the microparticle) which can therefore provide an opportunity for improved visualisation.

In this study, TPP-chitosan microparticles (loaded with red dye for visualisation purposes) have been used to attach to the lipid residues present in the latent fingerprint. In traditional fingerprinting techniques (e.g., ninhydrin), reagents react with salt, lipids, proteins, or amino acids present in the fingerprint residue. Although other polysaccharide-based systems may be more suitable (e.g., lipophilic polysaccharide esters [6]), the potential of chitosan for latent fingerprint development has been demonstrated previously [7, 8].

2. Materials and Methods

2.1. Materials. All chemicals were purchased from Sigma-Aldrich (Gillingham, UK) and used without further purification.

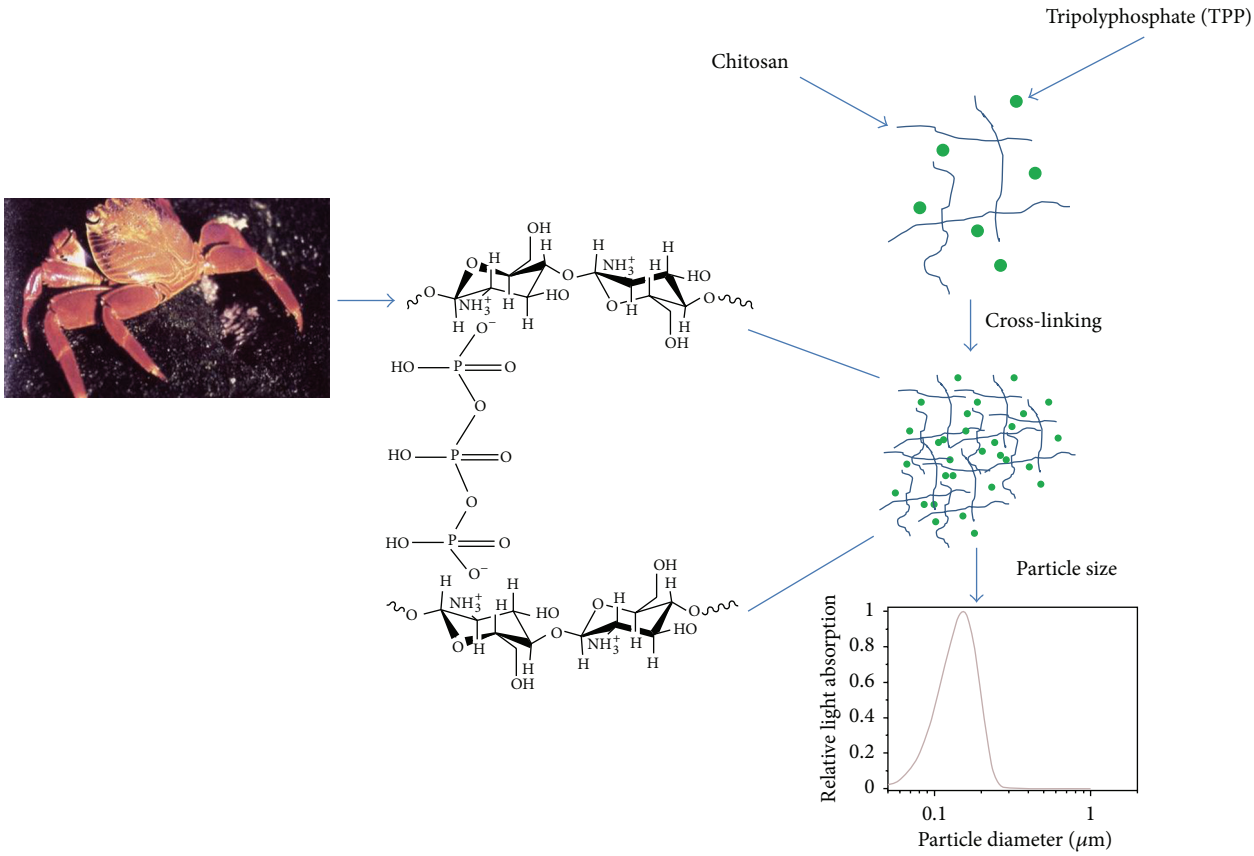

Figure 1: Formation of the tripolyphosphate-chitosan complex by ionotropic gelation [4, 5].

2.2. Sample Preparation. Chitosan (2.0 mg/mL) and tripolyphosphate pentasodium (0.84 mg/mL) were prepared in acetate buffer (0.2 M pH 4.3) as described in [2] and [4]. The resultant solutions were then mixed to give TPP : chitosan ratios of 1 : 6, 1 : 4, 1 : 2, 1 : 1, 2 : 1, 4 : 1, and 6 : 1, respectively, and the particle size distributions of the resultant microparticles were measured directly using a Malvern Mastersizer 2000 (Malvern Instruments Ltd., Malvern, UK) and under an optical microscope Leica DM 500 (Leica Microsystems, Milton Keynes, UK).

2.3. Fingerprint Enhancement. Latent fingerprint enhancement was investigated using the following protocol: the 7 different nanoparticle dispersions were centrifuged (Eppendorf UK, Stevenage, UK) at 4000 rpm for 90 minutes. After centrifugation, the supernatant was removed and the remaining of solid deposit was freeze-dried for 24 hours (Edwards High Vacuum International, Crawley, UK) after which the solid material was grounded with a pestle and mortar to produce powder suitable for fingerprinting. Fingerprints were then left on a glass slide as before and dusted with the TPP-chitosan powder.

3. Results and Discussion

When freshly prepared, the diameters of the TPP-chitosan particles were in the range 1–1000 μm (Figure 2) which is considerably larger than has been demonstrated in previous studies [4, 9–15] and may be explained in part by the molar mass and solubility of the chitosan. In so much as higher molecular weight chitosans produce larger particles [4, 15–18].

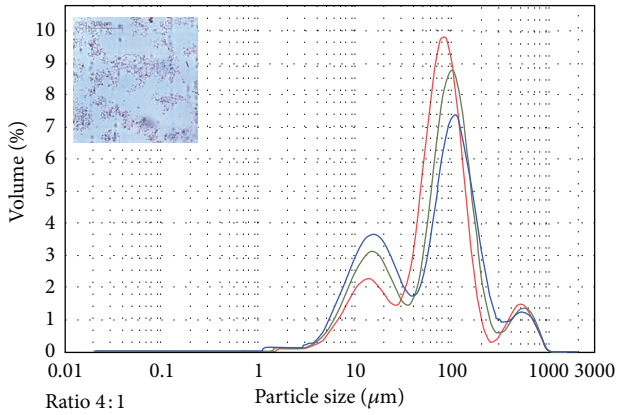

Figure 2: Particle size distribution (in triplicate) for TPP-chitosan in the ratio of 4 : 1. Inset a micrograph for the same sample.

It would appear that during sample preparation, the TPP-chitosan microparticles have aggregated. At this stage we have no apparent explanation; although we do not expect particle size to have a significant influence with respect to fingerprint

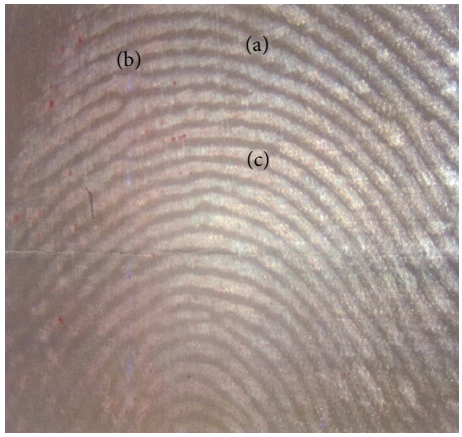

Figure 3: Latent fingerprint treated with TPP-chitosan (4 : 1). Some common features used for identification have been indicated: (a) ridge ending, (b) bifurcation, and (c) crossover.

enhancement. However, in any future applications the use of a stabiliser may be beneficial.

In the enhancement of latent fingerprints, it is only the sample with a TPP : chitosan ratio of 4 : 1 which gave satisfactory results (Figure 3). This is expected to be due to the effective charge on the particles [10], that is, as we increase the ratio of TPP, the particles will tend to lose their positive charge and it is expected that particles with little or no charge will interact to a greater extent with the lipids in fingerprint residues.

In Figure 3, the fingerprint details such as bifurcations and crossovers are clearly visible. As an alternative approach, fingerprints were left on a glass slides (nonporous surface) then immersed in the 7 different microparticle dispersions for 1 hour. The slides were then placed in drying oven for 45 minutes at temperature 80°C. However, this approach has not yet yielded any satisfactory results.

4. Conclusions

The use of TPP-chitosan in latent fingerprint enhancement was significantly affected by TPP : chitosan ratio, it was also expected that the storage temperature [4], concentration [18], molar mass [4, 15–18], and levels of aggregation, charge, and degree of deacetylation (DD) of chitosan will be of importance. Furthermore, it may be possible to form the microparticles directly on fingerprint in a 2-stage process. However, this new technique has the potential to be developed as a novel method for fingerprint enhancement.

Conflict of Interests

The authors declare that they have no conflict of interests.

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