

University of Huddersfield Repository

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

Latent Fingerprint Enhancement Using Tripolyphosphate-Chitosan Microparticles

Original Citation

Il Dueik, Issa M. A. and Morris, Gordon A. (2013) Latent Fingerprint Enhancement Using Tripolyphosphate-Chitosan Microparticles. International Journal of Carbohydrate Chemistry, 2013. pp. 1-4. ISSN 1687-9341

This version is available at http://eprints.hud.ac.uk/id/eprint/16848/

The University Repository is a digital collection of the research output of the University, available on Open Access. Copyright and Moral Rights for the items on this site are retained by the individual author and/or other copyright owners. Users may access full items free of charge; copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational or not-for-profit purposes without prior permission or charge, provided:

- The authors, title and full bibliographic details is credited in any copy;
- A hyperlink and/or URL is included for the original metadata page; and
- The content is not changed in any way.

For more information, including our policy and submission procedure, please contact the Repository Team at: E.mailbox@hud.ac.uk.

http://eprints.hud.ac.uk/

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

Received 14 November 2012; Accepted 27 January 2013

Academic Editor: Thomas J. Heinze

Copyright © 2013 I. M. A. Il Dueik and G. A. Morris. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

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 NH₂, 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 dyefunctionalized 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.

Tripolyphosphate (TPP)



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 μ m (Figure 2) which is



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

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].

It would appear that during sample preparation, the TPPchitosan 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.

References

 M. Rinaudo, "Chitin and chitosan: properties and applications," *Progress in Polymer Science*, vol. 31, no. 7, pp. 603–632, 2006.

- [2] A. M. Dyer, M. Hinchcliffe, P. Watts et al., "Nasal delivery of insulin using novel chitosan based formulations: a comparative study in two animal models between simple chitosan formulations and chitosan nanoparticles," *Pharmaceutical Research*, vol. 19, no. 7, pp. 998–1008, 2002.
- [3] G. A. Morris, M. S. Kök, S. E. Harding, and G. G. Adams, "Polysaccharide drug delivery systems based on pectin and chitosan," *Biotechnology and Genetic Engineering Reviews*, vol. 27, pp. 257–284, 2010.
- [4] G. A. Morris, J. Castile, A. Smith, G. G. Adams, and S. E. Harding, "The effect of prolonged storage at different temperatures on the particle size distribution of tripolyphosphate (TPP)chitosan nanoparticles," *Carbohydrate Polymers*, vol. 84, no. 4, pp. 1430–1434, 2011.
- [5] L. E. Chávez de Paz, A. Resin, K.A. Howard, D.S. Sutherland, and P.L. Wejse, "Antimicrobial effect of chitosan nanoparticles on *Streptococcus mutans* biofilms," *Applied and Environmental Microbiology*, vol. 77, no. 11, pp. 3892–3895.
- [6] S. Hornig and T. Heinze, "Efficient approach to design stable water-dispersible nanoparticles of hydrophobic cellulose esters," *Biomacromolecules*, vol. 9, no. 5, pp. 1487–1492, 2008.
- [7] N. Ul Islam, K. F. Ahmed, A. Sugunan, and J. Dutta, "Forensic fingerprint enhancement using bioadhesive chitosan and gold nanoparticles," in *Proceedings of the 2nd IEEE International Conference on Nano/Micro Engineered and Molecular Systems* (*IEEE NEMS* '07), pp. 411–415, January 2007.
- [8] J. Dilag, H. Kobus, and A. V. Ellis, "Cadmium sulfide quantum dot/chitosan nanocomposites for latent fingermark detection," *Forensic Science International*, vol. 187, no. 1–3, pp. 97–102, 2009.
- [9] A. Anitha, N. Deepa, K. P. Chennazhi, S. V. Nair, H. Tamura, and R. Jayakumar, "Development of mucoadhesive thiolated chitosan nanoparticles for biomedical applications," *Carbohydrate Polymers*, vol. 83, no. 1, pp. 66–73, 2011.
- [10] A. Nasti, N. M. Zaki, P. de Leonardis et al., "Chitosan/TPP and chitosan/TPP-hyaluronic acid nanoparticles: systematic optimisation of the preparative process and preliminary biological evaluation," *Pharmaceutical Research*, vol. 26, pp. 1918–1930, 2009.
- [11] Q. Gan, T. Wang, C. Cochrane, and P. McCarron, "Modulation of surface charge, particle size and morphological properties of chitosan-TPP nanoparticles intended for gene delivery," *Colloids and Surfaces B*, vol. 44, no. 2-3, pp. 65–73, 2005.
- [12] B. Hu, C. Pan, Y. Sun et al., "Optimization of fabrication parameters to produce chitosan-tripolyphosphate nanoparticles for delivery of tea catechins," *Journal of Agricultural and Food Chemistry*, vol. 56, pp. 7451–7458, 2008.
- [13] Y. Xu and Y. Du, "Effect of molecular structure of chitosan on protein delivery properties of chitosan nanoparticles," *International Journal of Pharmaceutics*, vol. 250, pp. 215–226, 2005.
- [14] H. Zhang, M. Oh, C. Allen, and E. Kumacheva, "Monodisperse chitosan nanoparticles for mucosal drug delivery," *Biomacromolecules*, vol. 5, no. 6, pp. 2461–2468, 2004.
- [15] M. L. Tsai, R. H. Chen, S. W. Bai, and W. Y. Chen, "The storage stability of chitosan/tripolyphosphate nanoparticles in a phosphate buffer," *Carbohydrate Polymers*, vol. 84, no. 2, pp. 756–761, 2011.
- [16] M. L. Tsai, S. W. Bai, and R. H. Chen, "Cavitation effects versus stretch effects resulted in different size and polydispersity of ionotropic gelation chitosan-sodium tripolyphosphate nanoparticle," *Carbohydrate Polymers*, vol. 71, pp. 448–457, 2008.

- [17] M. Luangtana-anan, P. Opanasopit, T. Ngawhirunpat et al., "Effect of chitosan salts and molecular weight on a nanoparticulate carrier for therapeutic protein," *Pharmaceutical Development and Technology*, vol. 10, no. 2, pp. 189–196, 2005.
- [18] E. S. K. Tang, M. Huang, and L. Y. Lim, "Ultrasonication of chitosan and chitosan nanoparticles," *International Journal of Pharmaceutics*, vol. 265, pp. 103–114, 2003.