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Synthesis of photo-polymerizable keratin from bird feather

Esmaiel Jabbari
University of South Carolina, USA

Statement of the Problem: Keratin is a family of fibrous proteins found in nature as the major component of wool, hair, horn, nail and hoof of mammals and birds feather. The disulfide crosslinks in combination with other structural features like crystallinity and physical interaction between the β-sheets impart high strength to feather. Due to its high strength and biocompatibility, membranes, sponges and fiber meshes have been produced from keratin. In this work, we describe the synthesis of a photo-polymerizable hydrogel for cell encapsulation based on the keratin extracted from barbs and barbules of chicken feather. The novelty is the synthesis of keratin allyl thioether macromer (KeratATE), based on the keratin extracted from feather that can be dissolved in aqueous cell suspension, injected, and photo-polymerized to generate hydrogels for surface coating and medical applications. Since keratin is rich in cysteine residues, s-allyl modification of sulfhydryl groups was used to functionalize keratin for chemical crosslinking.

Methodology: Keratin was extracted from feather barbs by reducing the disulfide bonds in cysteine residues to sulfhydryl groups (-SH) (Figure). Next, the free thiol groups were converted to dehydroalanine (Dha) by oxidative elimination using O-(2, 4, 6-Trimethylbenzenesulfonyl) hydroxylamine. Then, the Dha moieties were converted to s-allyl cysteine by reaction with allyl mercaptan to produce keratin allyl thioether (KeratATE) biopolymer. Conversion of allyl mercaptan before and after allylation reaction was quantified by 5, 5'dithiobis (2nitrobenzoic acid) (DTNB) test. The secondary structure of the extracted keratin before and after allylation was determined by circular dichroism and infrared spectroscopy. Molecular weight and purity of the extracted keratin was measured by gel electrophoresis and dialysis. Crosslinking kinetics and gelation point of KeratATE was measured by rheometry. Degradation of the crosslinked keratin was measured in aqueous solution supplemented with collagenase or trypsin.

Findings: The freeze-dried photo-crosslinked KeratATE hydrogels had a porous, interconnected, honeycomb microstructure. The compressive modulus of the hydrogels ranged from 1 to 8 kPa depending on KeratATE concentration. Degradation of KeratATE hydrogel was strongly dependent on trypsin concentration but independent of collagenase.

Conclusion: Keratin allyl thioether derived from feather is a viable alternative to collagen based biopolymers as a photo-polymerizable gel with controllable degradation for medical applications.

jabbari@mailbox.scs.edu

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