Self-Assembled Complexes Derived From Bioinspired Tannins

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Introduction: Tannins are naturally occurring macromolecular polyphenols that self-assemble with proteins and other biomacromolecules. Historically, they were used for leather making due to their ability to tan animal hides. They've also been shown to self-assemble with poly(ethylene glycol) (PEG) into hydrogen-bonded interpolymer complexes (IPCs)[1]. Naturally occurring tannins are difficult to obtain with sufficient purity for well controlled studies of IPC formation. In this work, synthetic tannins were produced with molecular structures that mimicked hydrolysable tannins. These tannins were used to make nanoscale colloids that disintegrate upon exposure to oxidative stress. They were also utilized in the crosslinking of gelatin into leather-inspired materials.

Methods: Synthetic tannins were produced using a two-step reaction as previously described[2]. First, dextrans were substituted with benzyl protected hydyroxybenzoic acids followed by Pd catalyzed deprotection under H_2. IPCs were formulated using synthetic tannins and commercially available linear and branched PEGs. Disintegration of IPCs in the presence of superoxide was determined using a xanthine oxidase (XOD) assay. Gelatin hydrogels were obtained by dissolving type B gelatin in water at 37°C with and without tannins followed by cooling at 4°C overnight.

Results: The stability of colloidal IPCs was determined by visual inspection, turbidity assays, and dynamic light scattering. Stability depended on polymer molecular weight, PEG branching, and PEG terminal groups. Stable, nanoscale colloids <200 nm in hydrodynamic diameter were generally obtained using star shaped PEGs with terminal carboxyl groups. All complexes displayed some antioxidant power when analyzed using the Folin-Ciocalteu method[3]. Only polygallol derived IPCs displayed redox responsive decomplexation in the presence of superoxide (Figure 1). Dissolution of some gelatin hydrogels with tannins was not observed 72 h after immersion in phosphate buffered saline. Dissolution of gelatin hydrogels without tannin or with tannin derived from dextran below 6 kDa was observed under the same conditions. All hydrogels were degraded in the presence of trypsin.

Conclusions: The design and use of bionspired tannins for self-assembling biomaterials in this suggests that a wider range of similarly designed polymers deserves further investigation. Biomaterials derived from these compounds may be useful for designing biodegradable implant materials with therapeutic antioxidant properties. They may also be useful for engineering smart nanomedicine which can target and respond to pathological oxidative stress.

References:

[1] H. P. S. Makkar, M. Blummel, K. Becker, British Journal of Nutrition 1995, 73, 897.
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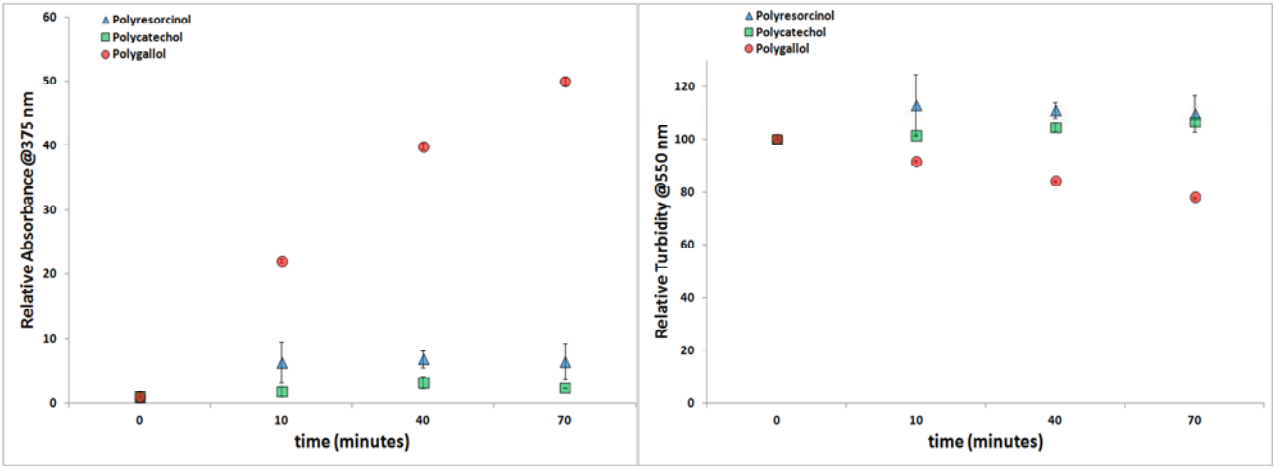

Figure 1 Xanthine oxidase (XOD) decomplexation assay of tannin-PEG complexes using 100 kDa linear PEG. (left) Time dependent changes in UV absorbance of IPCs in the presence of hypoxanthine and XOD due to superoxide oxidation. (right) Changes in turbidity over time of the same samples were determined by measuring absorbance at 550 nm. Data is expressed as a mean ± standard deviation (n=4).