Immediate shape-retentive wound dressings formed *in situ* using hydrogel nanoparticle powders

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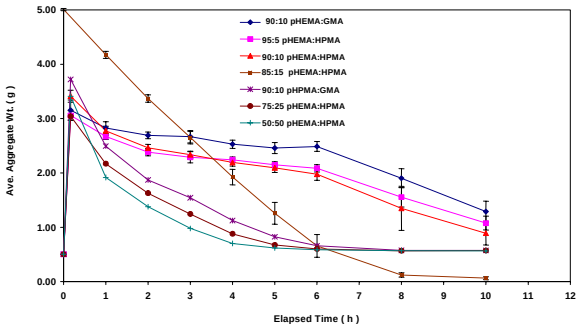
Statement of Purpose: The purpose of this research was to optimize the properties of hydrogel nanoparticle powders for use as self-assembling wound dressings. Hydrogel nanoparticle [HN] powders composed of different polymers were synthesized, and the resulting HN powders formed films when exposed to physiological fluids. The HN films were further characterized for fluid uptake, water loss, strength and subsequently for performance in a porcine skin wound healing model.

Methods: Nanoparticle polymers and copolymers were produced using an aqueous free radical polymerization process over 12 hr at 40ºC consisting of hydroxyethylmethacrylate, (HEMA), hydroxypropylmethacrylate (HPMA), glycerol methacrylate (GMA) and Methacrylic acid (MAA). Nanoparticle size was characterized using laser light scattering. The nanoparticle suspensions were lyophilized to produce pure powders. Different suspensions of nanoparticles were combined to produce nanoparticle mixtures that were lyophilized to form powder mixtures. The powders were milled and sieved to a uniform particle size.

HN powders form films instantly and irreversibly upon exposure to physiological fluids. Water uptake and losses were determined by gravimetric analyses. Rheological measurements were performed on films to evaluate strength and elasticity with hydration.

A porcine full thickness skin wound was generated using a surgical scalpel. Initial studies examined the HN film formation, tolerance and adhesion to the wound site. HN film performance was examined over time in full and partial thickness wounds [wound surface area and histological assessment] in comparison to commercial bandages.

Results/Discussion: Hydrogel polymer composition affected the relative amounts of fluid adsorbed by a given mass of polymer and the subsequent loss of water through evaporation as shown below:

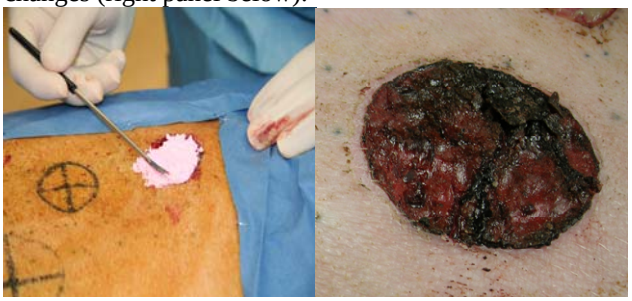


Measurements of breaking strength and elasticity of a variety of films indicated that the strongest films were formed of polymers that incorporated HPMA.

Nanoparticle Composition	Elastic Modulus (MPa)
pHEMA	1.1
pHPMA	2.7
95:5 pHEMA:HPMA	1.2
90:10 pHEMA:HPMA	1.2
85:15 pHEMA:HPMA	1.4
75:25 pHEMA:HPMA	1.9

Likewise, it was determined that mixtures of pHEMA and pHPMA nanoparticles yielded films with similar strength and water uptake/loss as films formed from comparable copolymers.

HN powders of HEMA and HPMA at ratios between 75:25 HEMA:HPMA and 90:10 HEMA:HPMA instantly formed shape-retentive and shape-conforming wound dressings over both partial and full thickness skin wounds, (left panel below). In the absence of any secondary coverage, HN film dressings were water-resistant, adherent, and provided a moist wound healing environment up to 28 days, without any wound dressing changes (right panel below).



Conclusions: The results indicate that viable wound dressings can be produced *in situ* using HN powders and the physical properties and performance can be altered and optimized by changing the composition of the lyophilized nanoparticle powder.

The HN films require no secondary dressings and no wound dressing changes (every 4-8 hrs for commercial dressings). Of importance is the ability of HN films to be shape-conforming to various wound types and depths, while promoting re-epithelialization without an immune response.

These findings led to the commercial scale production of nanoparticle powder composed of 85:15 pHEMA : pHPMA for use as an advanced woundcare dressing and for application in a Phase IV clinical study.

This technology now provides a platform for developing unique HN film wound dressings to further optimize and accelerate wound healing; i.e., chronic wounds or trauma applications.