## Engineering Biomedical Materials from Corn and Wool

Clarkson Univ. (Potsdam, NY; www.clarkson.edu) polymer chemist Anja Mueller is using a uniquely branched polymer with both hydrophilic and hydrophobic parts to bioengineer an artificial skin scaffold that promotes tissue regeneration and directs cell growth for hair follicles and sweat glands. Concurrently, Craig Woodworth, a cell biologist and associate professor at Clarkson Univ., is focusing on isolating a combination of cytokines (naturally occurring proteins that regulate the growth of specific cells) that will stimulate skin growth and promote wound healing.

Mueller's approach involves incorporating the cytokines into the polymer scaffold before it is assembled, allowing for a steadier, more controlled release of the cytokines than the traditional method of adding the cytokines after the scaffold is assembled The cytokines of interest include epidermal growth factor, which stimulates cells to grow quickly, filling in the wound; vascular endothelial growth factor, which stimulates blood vessel formation; and Transforming Growth Factor-B1 (TGF-B1), which regulates production of collagen and connective tissue proteins. "Although results for TGF-B1 look promising, the expression of this protein after the initial healing has occurred contributes to scarring," says Woodworth. "Therefore, the trick may be to turn TGF-B1 on initially, and deactivate it when the skin begins to return to its normal structure and function," he adds.

The structural integrity and solubility of keratin, as well as its natural biocompatibility, controllable biodegradability and bioactivity makes it an ideal material for medical polymers. Against this backdrop, Jackson, MS-based plastic surgeon, Robert Allen Smith proposed that keratin extracts from hair and wool could be used as platform technology to make a new family of biomaterials used for biomedical applications, such as wound healing and bone regeneration, scaffolds for tissue engineering, and coatings for medical devices. Challenging the long-standing notion that these animal-derived proteins would not be compatible with human biological systems, Smith proved that the carefully extracted keratin molecule did not elicit an adverse biologic response , and, in 1996, founded Keraplast Technologies Ltd. (San Antonio, TX; www.keraplast.com) to bring his vision to fruition.

The firm's extraction technology is based on oxidative and reductive techniques (vs. hydrolysis) that make the keratin molecule soluble before it is cross-linked to fabricate the desired material. "This chemical manipulation is possible because of keratin's high sulfur content and the use of sulfur as a cross-linker in the keratin molecule," says Smith.

Keraplast plans to develop wound-healing and orthopedic products with New Zealand-based Keratec Ltd. (www.keratec.co.nz), the core technologies of which involve the extraction and purification of intact fractions of natural keratin proteins and lipids from wool sources. Keraplast has also partnered with the school of polymers and high-performance materials at the Univ. of Southern Mississippi to perform R&D work on keratin proteins and product development.