Silk-based bioactive wound dressing and skin graft

The peptides reduced the population of both Gram-positive and Gram-negative bacteria and stopped their growth, say Biman Mandal (right) and Dimple Chouhan. | Photo Credit: Picasa

Researchers at the Indian Institute of Technology (IIT) Guwahati have developed bioactive wound dressings and bio-artificial skin by using silkworm silk fibroin as matrix and coating it with recombinant spider silk proteins. If animal trials are also successful, the wound dressing might help in treating chronic and severe wounds such as diabetic foot ulcers, while skin graft might come handy for burn patients.

Wound dressings

While wound dressings reduced bacterial population by nearly fourfold and showed good anti-biofilm properties, the silk scaffolds seeded with human dermal and epidermal cells led to the development of bio-artificial skin. The team led by Prof. Biman Mandal from the Department of Biosciences and Bioengineering also vascularised (develop blood vessels) the bio-artificial skin by using human dermal microvascular endothelial cells. The results of the study were published in the journal *ACS Applied Materials & Interfaces.*

Nanofibrous silk mat for wound dressing was prepared using silkworm fibroins as the matrix and was coated with 0.1 mg/ml of recombinant spider silk proteins containing antimicrobial peptides, cell binding protein and growth factor peptide. Whereas the growth factor stimulates cell proliferation and recruits cells to the site of wound, the cell binding protein also helps in recruiting cells to the wound site and in the cell migration process.

“The spider silk has high affinity towards silkworm silk and so readily self-assembles as a thin coating on top of the matrix without the use of any chemicals. Since the interaction between spider and silkworm silk is strong the coating remains stable,” says Dimple Chouhan from IIT Guwahati and first author of the paper. Both mulberry and non-mulberry silk varieties were suitable for producing the matrix, with the non-mulberry silk showing quicker and stronger self-assembly with spider silk.

If silkworm silk matrix is directly functionalised then more volume of the active compounds will be required and tunable delivery of the compounds will also be difficult.

The functionalised spider silk used in the study was developed by Dr. My Hedhammar from KTH Royal Institute of Technology, Stockholm, Sweden, and coauthor of the paper.

The two cationic peptides — Magainin I and Lactoferricin — contained in the spider silk-coated silk mats showed good antibacterial activity against two of the most common bacteria found in wounds — Pseudomonas aeruginosa and Staphylococcus epidermidis. “The cationic peptides are non-specific and so can target most bacteria present in the wound. We tested the peptides against both Gram-positive and Gram-negative bacteria and the peptides reduced the population of both and stopped bacterial growth,” says Prof. Mandal. The peptides did not allow biofilm formation till the end of 24 hours of study.

Since chronic wounds lack cell binding proteins and growth factor to recruit skin cells to the site, the healing gets delayed or obstructed. But the presence of these proteins and antimicrobials in the coated silk mat helped the team achieve “functionally active mats” for wound dressing.

Skin grafts

To develop bio-artificial skin grafts, a soft, porous scaffold made of silkworm silk protein was coated with recombinant spider silk protein containing RGD proteins that promote cell binding and proliferation. Under *in vitro* conditions, the scaffold was cultured with human dermal (fibroblasts) and epidermal (keratinocytes) skin cells. While the dermal and epidermal skin cells led to the development of a bilayer skin graft, blood vessels were formed in the skin graft by culturing the scaffold with human dermal microvascular endothelial cells.

“We maintained the scaffold co-cultured with two skin cells types and blood vessel-forming cells for 21 days and developed skin grafts,” says Chouhan. “We could mimic both the epidermal and dermal layer of the skin and thus come up with a facile, efficient and affordable way to develop functionalised constructs for tissue engineering and possible drug screening applications.”

“We are currently performing follow up studies using various animal models to examine the efficacy of bioactive constructs, to understand the healing properties and study cell-material interactions,” Prof. Mandal says.

The new findings show that Einstein’s insights into gravity still hold sway, even in one of the most extreme scenario.

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