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Introduction to microneedles

Ryan Donnelly, [a] Ester Caffarel-Salvador, [b] Harvinder Gill [c] and Hyungil Jung [d]

Microneedle arrays (MN) are minimally-invasive devices that painlessly, and without drawing blood, by-pass the skin's *stratum corneum* barrier, thus allowing deposition of materials in the viable skin layers. MN (50–900 μm in height, up to 10 000 MN cm^{-2}) of various geometries and materials (silicon, metal, polymer) are produced using microfabrication. Polymeric MN release their drug payload as they swell, dissolve or biodegrade in the viable skin layers. *In vivo* studies using MN have demonstrated delivery of oligonucleotides, hormones and other potent substances, reduction of blood glucose levels from insulin delivery and increase of skin transfection with DNA. However, the vast majority of work in this field has historically been concentrated on intradermal vaccine delivery. This is hardly surprising, given the potential for stable, dry-state formulation, the avoidance of needle-stick injuries common with hypodermic syringes, dose-sparing through direct targeting of viable skin's abundance of specialised antigen-presenting cells and the self-disabling nature of dissolving MN. Increasingly, however, researchers in academia and industry are exploring MN as a means for drug delivery, biosensing and wound management, amongst a plethora of other applications. That MN can be applied to skin by patients themselves, rather than a healthcare worker, provides opportunities for home care, increasing patient convenience and reduced costs for healthcare providers. While the MN field developed fairly slowly after the publication of the first academic paper in ref. 1, recent progress has been brisk. Extensive clinical trials are currently underway and manufacture has moved out of university laboratories and into contract manufacturing organisations' good-manufacturing-practice environments. The ref. 2 organisation has brought together MN developers, manufacturers, regulatory authorities and pharmacopoeial experts through their Centre of Excellence for Microarray Patches with a view to accelerating translational development and speeding up access for patients. While the first MN products to make it to market are likely to be fairly simple formulations based on existing pharmaceutical excipients, the next generation of products may be based on more complex or stimuli-responsive systems. It is on this cutting edge of the field that this collection is based.

MN show great promise as blood-free biosensors with a wide variety of applications. The review of Wang *et al.* (**https://doi.org/10.1039/D3BM00463E**) discusses progress made in glucose biosensing, while the experimental paper of Deng *et al.* (**https://doi.org/10.1039/D3BM00780D**) presents novel approaches to demand-based drug delivery; Li *et al.* (**https://doi.org/10.1039/D2TB02142K**) study cholesterol measurement, while Ajmal Mokhtar *et al.* (**https://doi.org/10.1039/D3TB00485F**) demonstrate electrochemical skin sensing and Shi *et al.* (**https://doi.org/10.1039/D2TB02600G**) use surface-enhanced Raman scattering to observe drug delivered into skin from a MN patch

The experimental papers of Wang *et al.* (**https://doi.org/10.1039/D2BM01836E**), Jiang *et al.* (**https://doi.org/10.1039/D2BM01937J**) and Anjani *et al.* (**https://doi.org/10.1039/D2BM01068B**), as well as the review of Zheng *et al.* (**https://doi.org/10.1039/D3TB01441J**), all describe novel MN-based approaches to management of gout and other musculoskeletal conditions.

Advanced materials are often defined as those that are specifically engineered or synthesised to exhibit novel or enhanced properties that confer superior performance relative to conventional materials. In drug delivery and biosensing, advanced materials are often combinations of several conventional or newly synthesised substances, often polymers. The reviews of Malek-Khatabi *et al.* (**https://doi.org/10.1039/D3BM00795B**) and Zhang *et al.* (**https://doi.org/10.1039/D2TB00905F**) and the experimental papers of Tobin and Brogden (**https://doi.org/10.1039/D3BM00972F**), Chen *et al.* (**https://doi.org/10.1039/D3BM00182B**), Aung *et al.* (**https://doi.org/10.1039/D3BM00132F**), Fu *et al.* (**https://doi.org/10.1039/D2TB02613A**), Li *et al.* (**https://doi.org/10.1039/D3TB00127J**), Zhang *et al.* (**https://doi.org/10.1039/D2BM02096C**), Zhao *et al.* (**https://doi.org/10.1039/D2BM01454H**), Abu-Much *et al.* (**https://doi.org/10.1039/**

[a]Queen's University Belfast, Ireland
[b]Chiesi, USA
[c]Texas Tech University, USA
[d]Yonsei University, Korea

D2BM01143C), Unver *et al.* (**https://doi.org/10.1039/D2TB01648F**) and Li *et al.* (**https://doi.org/10.1039/D2BM01275H**) all discuss the use of novel advanced materials in MN systems, demonstrating enhanced performance.

MN could be used to improve treatment of wounds and scars, as indicated in the review from Zhao *et al.* (**https://doi.org/10.1039/D3BM00262D**) and the experimental papers of Hu *et al.* (**https://doi.org/10.1039/D2TB02596E**), Cai *et al.* (**https://doi.org/10.1039/D2BM02101C**), Gao *et al.* (**https://doi.org/10.1039/D2BM01588A**) and Huang *et al.* (**https://doi.org/10.1039/D2BM01631A**). Nesovic *et al.* (**https://doi.org/10.1039/D3BM00305A**) and Lee *et al.* (**https://doi.org/10.1039/D3BM00377A**) describe novel approaches to MN vaccination.

We believe that these exciting studies demonstrate considerable progress in the microneedle field and we hope that you enjoy reading through the collection.

References

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2 PATH. Centre of Excellence for Microarray Patches. **https://www.path.org/resources/path-center-excellence-microarray-patch-technology/**, accessed 24th August 2023.