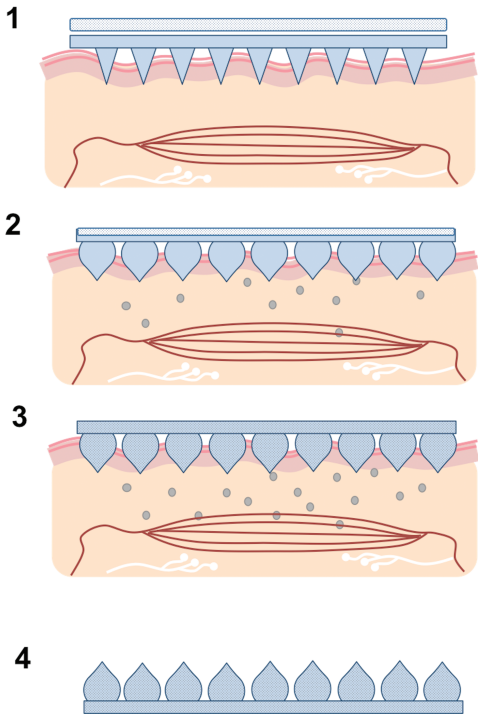

Fig. 2. Schematic illustration of the mechanism of action of hydrogel-forming microneedles.

rate of microneedle swelling, thus conferring the ability to govern drug release rate, which can be tailored for specific drugs. As with other microneedles, hydrogel-forming microneedles are painless and blood-free upon application, with the additional benefit of being removed intact from the skin following use, thereby depositing no measurable residual polymer. Importantly, however, the microneedles are suitably softened by the interstitial fluid, preventing reinsertion of the array, thereby reducing the risk of infection transmission that may arise from needle reuse.

Materials and manufacture

The first hydrogel-forming microneedles were manufactured using aqueous blends of specific polymeric materials, namely poly(methyl vinyl ether-co-maleic acid) (PMVE/MA), cross-linked with poly(ethylene glycol) (PEG) (Donnelly et al. 2012). Upon heating, these two polymers undergo an esterification reaction (Fig. 3) to produce a cross-linked material, confirmed using attenuated total reflectance (ATR)-Fourier transform infra-red (FTIR) spectroscopy and the observation of a carbonyl peak shift from 1708 to 1731 cm^{-1}, due to formation of an ester carbonyl (Luppi et al. 2003; Thakur et al. 2009). The swelling and network parameters of the hydrogels formed by the cross-linking of PMVE/MA with PEG have been extensively characterized, investigating the effect of PEG molecular weight, as well as differing ratios of the two components (Thakur et al. 2009). Using a high molecular weight PEG (1,000–10,000