Development of Gellan Gum Blend Fluid Gels as Topical Formulations
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Purpose
The aim of this investigation was to explore the potential of fluid gels for topical drug delivery. Fluid gels are suspensions of gel particles prepared by introducing a shear field in biopolymer solutions while gelation is occurring. The resultant material consists of gelled microparticles in an aqueous solution which can be formulated to act as a deformable viscoelastic gel while retaining gel characteristics at the micro level. Mixtures of low acyl (LA) and high acyl (HA) gellan gum were used to form the fluid gel, entrapping diclofenac sodium, a non-steroidal anti-inflammatory drug (NSAID).

Methods
Fluid gels were prepared by adding precise amounts of HA and LA gellan gum to deionised water at 85°C containing 1.16% of the NSAID drug and 0.5% NaCl while stirring. Once fully dissolved, the solutions were allowed to cool at 2 °C min⁻¹ whilst being sheared using a Bohlin Gemini Nano HR rheometer at a shear rate of 500 s⁻¹. Once cooled, the fluid gels were stored at room temperature prior to use.

Viscosity measurements of all samples were taken at 20 °C across shear rates ranging from 100 to 1000 s⁻¹ using a Bohlin Gemini HR Nano Rheometer fitted with a 55 mm cone and plate geometry. Results were compared with those of the commercially available Voltaren® gel.

Stress sweep rheological studies were used to determine the yield stress of different gel formulations to predict the stress required to initiate flow. The stress was gradually increased from 0.1 to 1000 Pa at 10 rad s⁻¹ angular frequency, at 20 °C, using the same geometry as the viscosity measurements.

Results
To mimic the rubbing and spreadability predictions for topical products, application shear rates tend to be between 100 to 1000 s⁻¹. The viscosity profiles of 1% w/w HA, LA and their mixtures in 0.5% w/w NaCl and Voltaren® gel all exhibit shear thinning behaviour; gellan gum formulations show slightly greater shear thinning, possibly a consequence of the relatively high spreadability of gellan (result not shown). It has previously been reported that the stress sweep can reflect the gel strength and yield stress of hydrated polysaccharides. Stress sweeps for 1% gellan fluid gels crosslinked with 0.5% NaCl, as function of HA:LA ratio, and for Voltaren® gel are shown in Figure 1. LA gellan has a lower yield stress and greater elasticity while HA gellan has a similar elasticity as the Voltaren® gel but with a higher yield stress. Interestingly the 50:50 LAHA blend of gellan exhibited a similar elasticity and yield stress to Voltaren® gel. Despite the 50:50 LAHA gellan fluid having a lower viscosity, it has the same rigidity and yield stress as the commercial Voltaren® gel formulations. Thus, the same force will be required to squeeze the product from the tube prior to application onto the skin.

Conclusion
In this study we have demonstrated that a fluid gel, comprising a blend of low acyl and high acyl gellan, has the potential to be used as a topical formulation with improved spreadability, similar rigidity and the potential for desirable skin sensation compared with the commercial gel.