THE EFFECT OF ADDITIVES ON THE RHEOLOGICAL PROPERTIES OF TRACHEAL MUCUS

C. Marriott and M. Litt*, Department of Pharmacy, University of Nottingham, Nottingham and *Department of Bioengineering, University of Pennsylvania, Philadelphia, U.S.A.

Previous studies with agents which affect the rheological properties of mucus have involved the use of sputum from diseased patients (Marriott and Kellaway, 1975). The heterogeneous nature of sputum dictates that some homogenisation process must be used before a realistic evaluation of any additive can be made. In this work we describe the use of tracheal mucus to evaluate the effect of pH, ionic strength and some mucolytic agents on mucus structure.

Mucus was obtained from adult, healthy beagle dogs which had been equipped with a tracheal pouch (Wardell and others, 1970). The fresh mucus was dialysed against distilled, deionised water and freeze dried. 3% w/v gels were reconstituted in buffer and allowed to equilibrate for 48h at 4°. Additives were dissolved in the buffer prior to reconstitution. Dynamic rheological experiments were carried out at 25° using a magnetic microrheometer over the frequency range 0.02 to 40 Hz. The rate of transport of the gel on a ciliated epithelium was determined using the bullfrog palate model (Shih and others, 1977).

Phosphate (I) and Tris/HCl (II) buffers were used as reconstitution media and in both cases homogeneous gels were produced with less than 5% variation between replicates. The effect of change in pH was to produce a minimum in the storage modulus (G') and the loss modulus (G") in the pH range 6.5 to 8.0. The gels were less sensitive to changes in ionic strength since the concentration of II could be reduced to 0.05 M before an increase in rheological moduli occurred. Although the use of unbuffered sodium chloride solutions (0.01 - 0.15 M) produced small changes in rheological properties, different transport rates occurred on the frog palate. For this reason isotonic phosphate buffer (pH 7.0) was used in all subsequent experiments.

A range of concentrations of sodium dodecyl sulphate (SDS), urea, and N-acetyl-cysteine (NAC) all produced decreases in G', G" and palate transport rate and in each case a concentration could be identified which produced an optimum effect. Potassium iodide produced no effect at concentrations of up to 0.45 M which would suggest that mucus gel structure is not maintained by ionic cross-links. NAC produced an 86% decrease in the moduli whereas the greatest effect that could be obtained with urea and SDS was 50%. It would appear therefore that disulphide, hydrogen and hydrophobic bonds are all involved in the mucus gel structure, although the first mentioned are the most significant. In contrast, S-carboxymethyl cysteine in concentrations of up to 1% produced no effect and presumably acts as a pro-drug which must be hydrolysed to an active form.

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