THE INFLUENCE OF SURFACE FREE ENERGY AND MICRORUGOSITY ON THE ADHESION OF BACTERIA TO POLYMER MONOFILAMENTS

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Bacterial adhesion to polymer substrates has frequently been related to the surface free energy (sfe) of the material; adhesion being greatest at low or high sfe with minimal adhesion occurring over an intermediate range (Dexter 1979). However many of the previous studies have been performed on pure, clean materials free of dye, plasticisers and other additives and, also little attention has been given to other parameters such as surface roughness. We have investigated the sfe and microrugosity of the monofilaments which are used as locating threads attached to intrauterine contraceptive devices (IUCDs) and also of polyvinylidine chloride (PVDC) monofilament and attempted to assess their relative importance in bacterial adhesion.

The sfe of a material is approximated by its critical surface tension. Thus, contact angles (θ) were measured for a series of organic liquids on each IUCD thread (polypropylene (PP), polyethylene (PE) and nylon) as well as PVDC monofilament. Zisman plots were made of $\cos\theta$ against the liquid surface tension for each thread. Values obtained were : PP = 39.00 mN m^{-1}, PE = 41.95 mN m^{-1}, nylon = 44.30 mN m^{-1} and PVDC = 48.38 mN m^{-1}. These values are different from literature values of pure polymers but other workers have also found marked differences between ideal and commercial materials (van Pelt et al 1984). Surface microrugosity of the threads was investigated using scanning electron microscopy and were ranked in order of increasing roughness PP < PE < nylon, while PVDC exhibited extensive smooth areas and distinct score marks.

Two methods were used to investigate the extent of bacterial adhesion. ^{3}H-thymidine labelled bacterial cells suspended in ¼ Ringer were incubated with threads at 37°C for 2 hours. The threads were removed, washed 3 times in Ringer and then incubated with 0.1 N NaOH for 1½ hours to remove adherent bacteria, and numbers assessed by scintillation counting. S.aureus was found to adhere in greatest numbers per unit area to nylon thread (2.8×10^{6} cm^{-1}). Approximately 90% of this amount adhere to PE and only 25 % to PP. Far fewer E.coli cells were found to adhere to the threads, with the highest number adherent to PE and approximately 25% of this amount adherent to the PP and nylon threads. Threads were also incubated with bacterial cells and then fixed in glutaraldehyde, dehydrated through a graded ethanol series and observed under the scanning electron microscope. Results obtained supported those from the radiolabelled method. It was observed that cells were largely seen adhering in the rough grooves and crevices as compared to the smooth areas. This was most apparent on the PVDC monofilaments.

It thus appears as though both surface microrugosity and sfe are important factors influencing bacterial adhesion. S.aureus cells adhered far less to PP thread compared to nylon and PE than would be expected if only sfe was considered. The fact that the PP monofilament was relatively smooth is indicated as an important factor and this is confirmed by the SEM micrographs of PVDC showing bacteria adhering to the rougher as opposed to the smoother areas. E.coli adhered less well to nylon than might have been expected which may indicate the influence of sfe.

Dexter, S.C. (1979) Journal of Colloid & Interface Science 70(2):346-354
A.W.J. van Pelt et al (1984) In: Bacterial adhesion and preventive dentistry. Ed. J.M. ten Catre, S.A. Leach & J. Arends, IRL Press Ltd., p 167-177