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Conduction of bacteria and blood cells through polycarbonate sieves

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We have developed the polycarbonate sieves (Makrofol-KG of thickness 30μm and 60μm) with precisely controlled pore size to filter bacteria of various types in the contaminated water and malignant cells in the human blood. It has been observed that the electric conduction through polycarbonate sieves depends upon the concentration of the contaminants and pore diameter of the sieve. The resistance of bacteria and malignant cells fluid decreases with increase of pore diameter in case of multi-pore as well as single-pore filters. It has also been observed that the relative resistance increases with the increase of infected blood cell or pollutant concentration in fluid.

Nuclear track microfilters have found wide applications in biological, environmental and chemical sciences[1-3]. Since most of the contaminants in drinking water and blood are pathogenic, it is imperative that the drinking water and human blood are free from these pathogens[4]. There exist quite a number of methods to eliminate these pathogens, viz. heating, irradiation with uv light, γ-ray exposure, bactericide and filtration with traditional filters. The most widely used filter types are fibre filters and membrane filters, but their pore sizes are not uniform in dimension and do not have a sharp limit to differentiate the size of bacteria and other solid particles. The nuclear track microfilter is an ideal type, its superiority over any other filter is its uniform pore size, which makes it possible to remove all pathogens bigger than the pore size[5,6].

To examine the properties of the sieves in relation to the conduction of pollutants through them, the polycarbonate sieves used here are multi-pore and single-pore having different diameters. Their effectiveness is checked by using them in purifying the contaminated water and blood with the help of a conductivity cell.

Development of microfilters-Makrofol-KG polycarbonate plastic sheets of thickness 30μm and 60μm were exposed to ^{132}Xe ions of energy 5.9 MeV/u from UNILAC, GSI, Darmstadt, Germany, at normal incidence, for preparation of both multi-pore and single-pore filters. The irradiated foils have been etched in 6.25N NaOH at 70°C for varying intervals of time to obtain micropores of desired diameters. After washing and drying, the pores were observed under a Carl Zeiss binocular optical microscope and the diameter of each pore was measured accurately using a calibrated graticule.

Culture of bacteria—The method used here for the growth of bacteria (E. coli and Colon bacilli) is Luria Broth (LB). For the preparation of culture, the media required are: trypton 5g, yeast extract 10 g, NaCl 10 g and distilled water 500 ml. After weighing the required amount of the media, it was dissolved in a conical flask of 500 ml containing distilled water. This solution was dissolved into 5 equal parts in 250 ml flasks and the stains of C. bacilli and E. coli were added into each flask by the method of inoculation. All the flasks were kept in a shaker for overnight at 30 °C and thus the new grown bacteria can be seen under an optical microscope. Knowing the size and shape of the bacteria its identification can be done.

Conduction of contaminants through microfilters—The contaminants mainly used here are:

(a) In water—E. coli (ball shaped) and C. Bacillus (rod shaped), both having diameter of 1μm.

(b) In Blood—The malignant blood cells of diameter in the range 7-15 μm.

The conduction effect through these polycarbonate sieves had been observed by using the conductivity cell (Fig. 1). The cell is designed in such a way that these filters act as a partition between the two chambers. A membrane partition served as a barrier to bacteria and cell migration and the change in current shows the resistance to the flow of the contaminants through the pores. The resistance through the pores of different diameters is measured

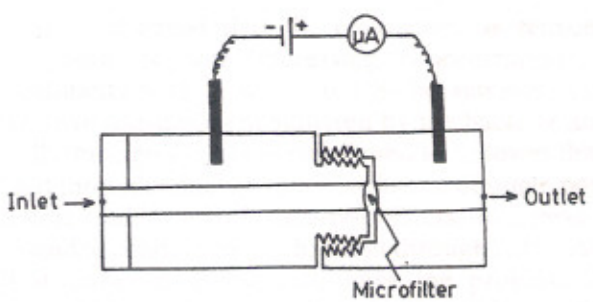

Fig. 1—Block diagram of conductivity cell

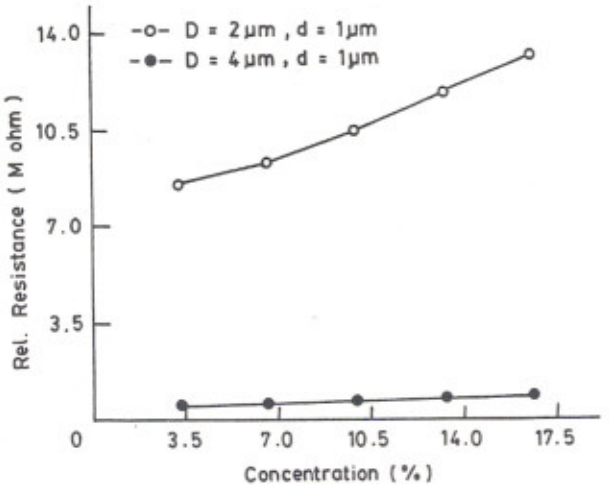

Fig. 2—Variation of relative resistance with concentration using multi-pore sieve for water sample

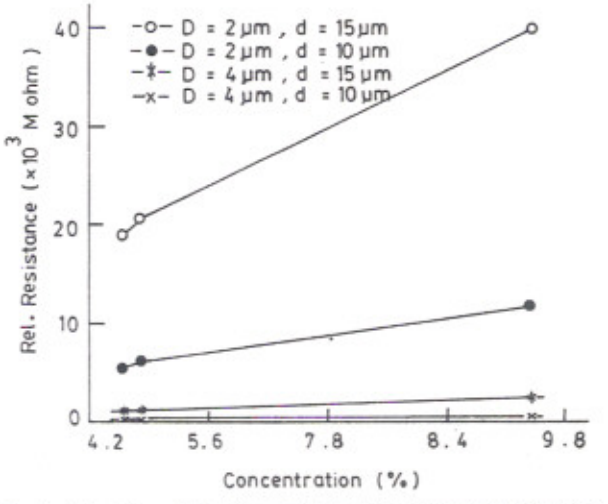

Fig. 4—Variation of relative resistance with concentration using multi-pore sieve for blood sample

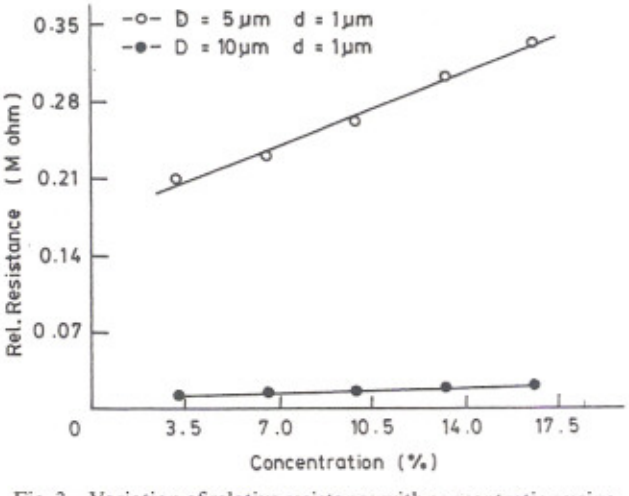

Fig. 3—Variation of relative resistance with concentration using single-pore sieve for water sample

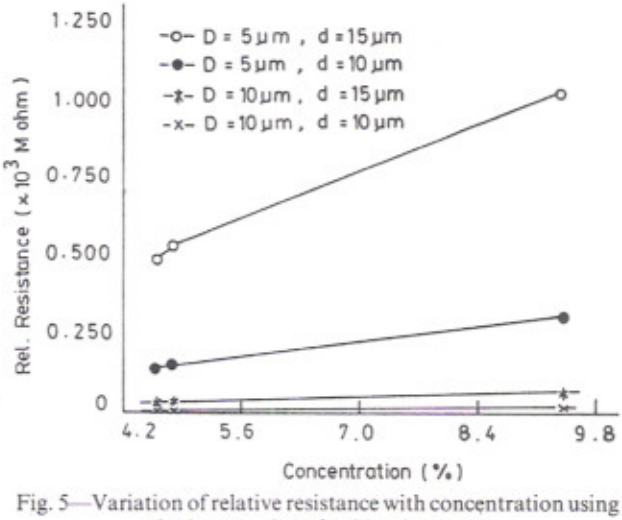

Fig. 5—Variation of relative resistance with concentration using single-pore sieve for blood sample

using Ohm's law, and the relative resistance ΔR with respect to pore diameter is obtained using formula[1], $\Delta R = 4\rho d^3/\pi D^4$ and the corresponding resistivity of the solution is found by $\rho = R A/l$, where, R is the resistance, A is the area of the cylindrical shaped conductivity cell and l is the length of the hole inside the cell. Taking different concentrations of the contaminated water and human blood, the conduction through the pores of different diameters had been measured.

The required diameters of microfilters used here are: multi-pore (2µm and 4µm), single-pore (5µm, 7µm and 10µm). The resistance between the two electrodes depends primarily on the conducting path through the pore. As a charged, insulating particle enters, the resistance increases by an amount proportional to the volume of the particle. Also the resistance through the pore is highly sensitive to geometry and is proportional to d^3/D^4, where d is the diameter of the particle and D is the diameter of the pore. In case of a spherical particle of diameter d, $\Delta R = 4\rho d^3/\pi D^4$ and ρ is the resistivity of the solution. The variations of relative resistance with concentration and pore diameter are shown in Figs 2 to 7.

It is observed that the conduction is reduced progressively with increasing concentration of pollutants both in water and blood samples. The relative resistance encountered by the bacteria and cells through a 10µm sieve is found to be lower than that through a 5µm or 7µm sieve in case of single-pore filters, and in case of multi-pore filters, 4µm sieve is found to conduct better than that through 2µm sieve. But since the blood cells have the property of deforming its shape while traversing through the

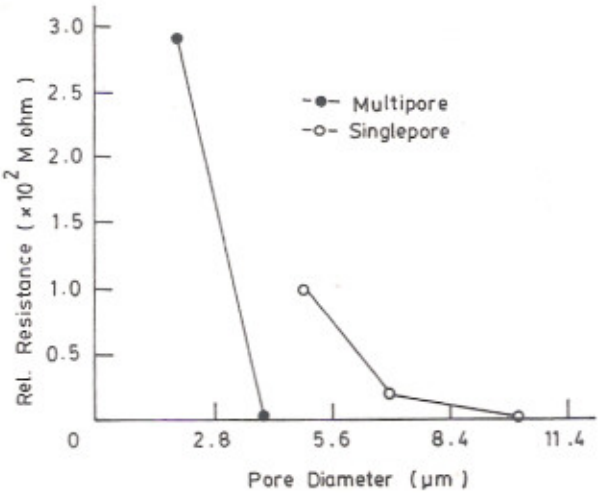

Fig. 6—Variation of relative resistance with pore diameter for water sample

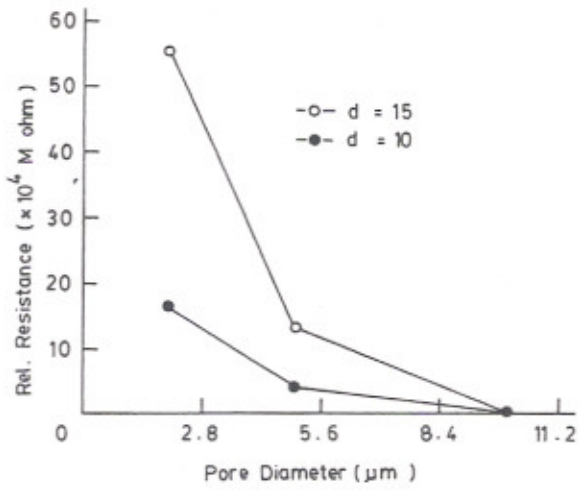

Fig. 7—Variation of relative resistance with pore diameter for blood sample

pores, therefore, the conduction in case of blood is better than in case of water and also the conduction of multi-pore filters is better than that of single-pore filters. Hence it is observed that as the concentration of polluted liquid increases the relative resistance also increases, and as the pore diameter of the filters increases, the relative resistance decreases.

Nuclear track microfilters (Makrofol-KG) are useful for removing pathogenic particles from polluted liquids. The contaminants may be in water, wine or beer, oil or in human blood. The removal efficiency depends upon pore size of the microfilter and also on the diameter of the pollutant but is independent of length. It is also helpful in determining the degree of pollutants in the contaminated liquids by controlling the pore size. The use of single pore membrane is valuable for the study of rigidity measurement of individual red blood cells. This is accomplished by applying a slight pressure differential across the diameter[7]. Further investigations are being carried out to identify and quantify the pollutants in water sample using single pore sensor.

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