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Applications of Ion Track Filters

S. Amrita Kaur[1], H.S. Virk[1] and S.K. Chakarvarti[2]

[1] Department of Physics, Guru Nanak Dev University, Amritsar - 143005, India

[2] Department of Applied Physics, Regional Engineering College, Kurukshetra, India

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Abstract

We have developed ion track filters/polycarbonate sieves of Makrofol-KG of thickness 30µm, 60µm and 100µm by ^{132}Xe and ^{238}U ion beam irradiation at 5.9 MeV/u and 14.0 MeV/u energy, respectively from UNILAC, GSI, Darmstadt. Both single pore and multipore sieves were prepared by etching the plastic foils in 6.25 N NaOH at 70°C for different intervals of time. E.Coli and C. Bacillus (dia. 1µm) and malignant blood cells (diameter 7-15µm) were filtered using a conductivity cell designed in our laboratory. Commercial exploitation is possible in developing countries for getting bacteria free water supply. Solute concentration of different solutions is determined using ion track filters. The next on our agenda is the template growth of micro/nano ensembles which will have an extensive range of applications in a variety of fields of science and technology.

Introduction

Solid State Nuclear Track Detector (SSNTD) technique is one of the most developed tools of research in a number of scientific and technological areas due to its wide range of applications in various interdisciplinary fields[1]. The first application that found widespread acceptance is the ion track filters[2,3]. The so produced ion track filters or membranes can be used in wide range of applications in various fields, viz. Biophysics, Nuclear physics, Health physics, Material Science and many others. The main advantage of these track filters over conventional filters is their well-defined pore size, and uniform density[4]. Due to possibility of reuse, these filters will prove to be very economical.

Preparation of Ion Track Filters

Makrofol-KG ($C_{16}H_{14}O_3$) was used for the preparation of ion track filters in the present experiment. Heavy ion beams of ^{132}Xe and ^{238}U were used for irradiation of 30µm, 60µm and 100µm thick makrofol polycarbonate foils from UNILAC, GSI, Darmstdt, Germany at an angle of 90° with fluences of 10^4 and 10^5 ions/cm^2 having energy 5.9 MeV/u and 14.0 MeV/u, respectively. These irradiated foils have been etched in 6 N NaOH at 70°C for varying intervals of time for production of single and multipore filters. After washing and drying of these samples, the pores were observed under Carl Zeiss binocular optical microscope. The pore diameters were measured using a calibrated graticule in the eye-piece.

Applications of Ion Track Filters

There are growing number of applications of nuclear track- etched filters/membranes in various branches of science and technology like ultrafiltration, separation of emulsions, as model pores for biological membranes, fabrication of metal micro tubes using ion track filters ,etc. In the present study, we describe some of these applications:

(i) Conduction of bacteria and malignant cells through polycarbonate filters

The conduction effects through these filters have been observed in various liquids viz., polluted water, normal water, contaminated blood, beer, sugarcane juice etc., by using the conductivity cell. The cell is designed in such a way so that these filters act as a partition between the two chambers, serve as a barrier to bacteria 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

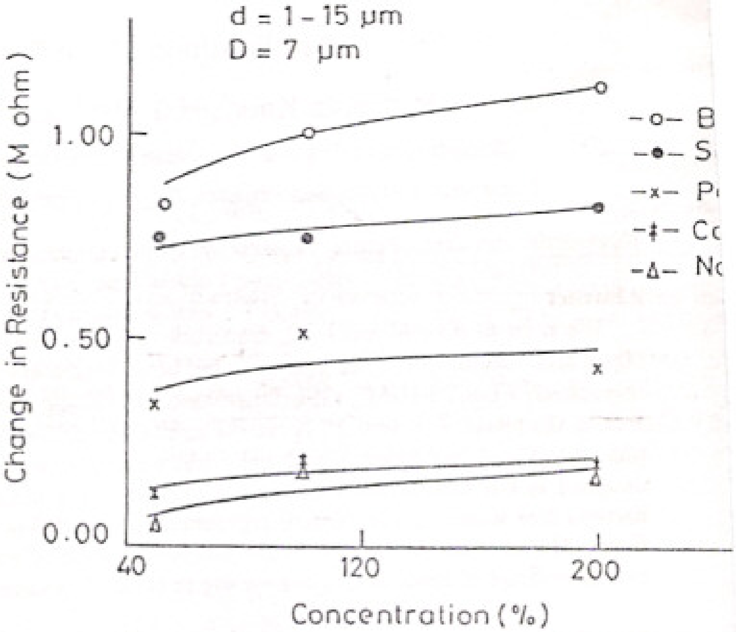

Fig. 1. Variation of change in resistance with concentration using single-pore filter for various liquids.

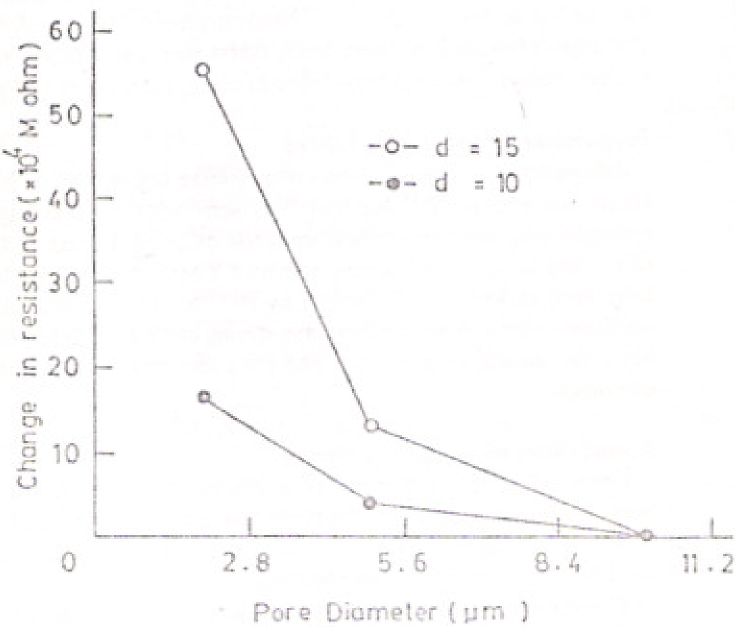

Fig. 2. Variation of change in resistance with pore diameter for blood sample

using Ohm's law, and the change in resistance ΔR with respect to pore diameter is determined by using formula[1], $\Delta R= 4\rho d^3/\pi D^4$, where d is the diameter of the particle and D is the diameter of the pore and the corresponding resistivity of the solution is found by $\rho=RA/l$, 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. It has been observed that conduction is reduced progressively with increasing concentration of contaminants provided one side of the cell is filled with the media (i.e. polluted water, normal blood, cancerous blood, beer, infected sugarcane juice) and the other side is filled with unpolluted water or normal saline solution.Thus the change in resistance relative to concentration increases only if negative polarity is given to the media and positive polarity to the unpolluted water or normal saline solution. it is also observed that as the pore diameter of the filter increases, the change in resistance decreases (figs. 1 and 2 for blood).

(ii) Microhydrodynamical flow studies in various liquids using ion track filters

We have made microhydrodynamical flow studies on various liquids (water, alcohol and acetone) using these filters. For this study, a self-designed apparatus is used for the estimation of solute concentrations in different mixtures with water as a base. It has been observed that the rate of flow, dV/dt, decreases with the increase of solute concentration. The variation of the dV/dt versus concentration of the solutes in water at a constant pressure difference is studied (fig. 3).

(iii) Characterisation of metal-semiconductor microstructures grown using ion track filters

There has been an ever increasing interest exhibited towards fabrication of nano/micro structures (metallic as well as non-metallic) mainly because of the many possible potential applications. Microstructures comprising either metallic microdimensional devices- dots, fibres, wire, cones, tubules and whiskers have invited attention for use as horizontal technology in multidisplinary areas such as microelectronic mechanics, field emission electrodes[6], electrochemistry, conductive polymeric fibrils, transparent metal structures, biological substitutes for microtubles nano and microstructures, etc. There exist a variety of techniques like electron/ion beam lithography, photolithography (optical, UV and X-rays), selective electroless metallic deposition technique etc. We have used the technique of template growth of microstructures of metal-semiconductor (Cu-Se) through the etched pores of ion track filters of Makrofol-KG.

In the present work, we describe the simple method of electrodeposition of copper metal into the etched pores of polymeric ITFs by using an electrochemical cell. The basic principal underlying this process is an electrochemical process in which metallic ions in a supporting solution are reduced to the metallic state at the cathode which if closely covered by an ITF, would lead to the growth of an electroplated film. The electrolyte used here is $CuSO_4.5H_2O$ acid solution in 10MΩ milli Q water + 25% vol H_2SO_4 and $Na_2SeO_3.5H_2O$ in 10 MΩ milli Q water. A current of 0.05 A/cm^2 was applied for 20 and 30 mins., respectively. After the plating process is over, the ITF is carefully removed, washed with distilled water and dried and is dissolved chemically in chloroform ($CHCl_3$). After drying, the thin film was carefully peeled off from ITF and sent for scanning. Two visible layers of Cu & Se were found to be deposited over the surface of ITF sandwiching the foil. In order to characterise these microstructures we have used AFM for finding out morphological and structural parameters (fig.4).

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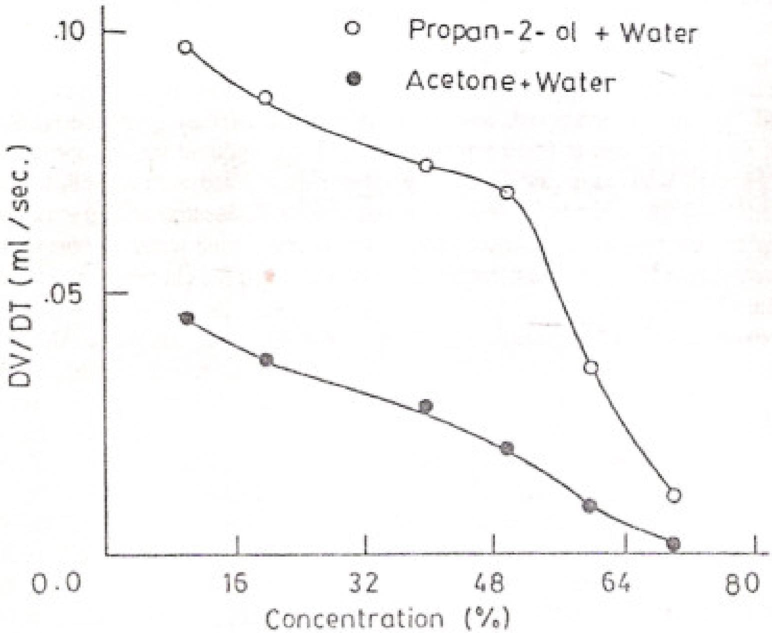

Fig.3. Variation of flow rate, dV/dt, with concentration of the solutes in water at constant pressure difference.

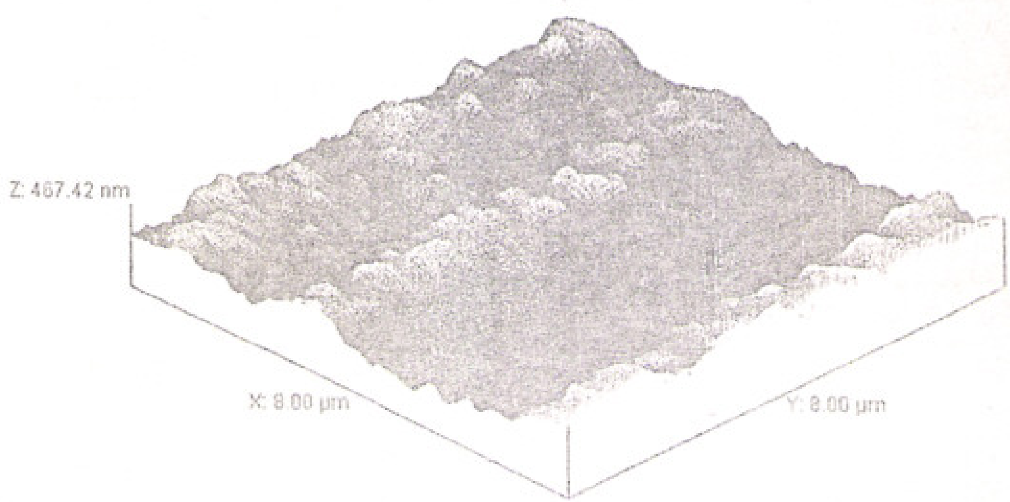

Fig 4 Microstructure ensemble (3-d) of Cu-Se grown electrochemically using ion track filters