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Resistivity Measurement of Teflon Doped with Sodium and Lithium

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ABSTRACT

Teflon is a polymer material and acts as an electrical insulator. But when doped with alkali metals like lithium and sodium, it has been found that there is a decrease in resistivity of the samples. A simple method has been described here to dope the Teflon chemically and observe the resistivity changes.

Key words: Resistivity, Teflon, Alkali metals, Tetrahydrofuran, Activation analysis.

INTRODUCTION

Nowadays, considerable amount of work is being carried out in the field of polymers and many workers are trying to obtain good quality conducting layer on a polymer. Alkali metals Lithium and Sodium are elements which when doped in a polymer changes the surface resistivity. Chemical methods are used to dope these metals on polymers.

MATERIAL AND METHODS

A Teflon sheet of 2mm thickness was cut in pieces of area 1cm^2 and were cleaned using chemical treatment. These pieces were irradiated before and in some instances after the doping of sample with Lithium or Sodium in order to see the effect of irradiation on the resistivity of the samples with the following sources as shown in Table 1. The irradiation was carried out for duration enough to get good fluence.

A solution[1,2] was prepared to dope the samples with Lithium or Sodium. This solution was prepared by taking 100ml of dry Tetrahydrofuran (THF) and adding 0.05mol(6.4gm) of Napthalene. After this 0.1mol of either Lithium or Sodium is taken and stirred in the naphthalene added Tetrahydrofuran solution. A dark greenish blue solution is formed. This solution of Lithium or Sodium is taken and the unirradiated and pre-irradiated Teflon samples are dipped into it and taken out after 1, 2, 3, 4 and 5 days in small batches of four samples of each group.

The amount of Sodium or Lithium doped on the sample was estimated by weighing the sample before and after dipping in the Sodium or Lithium solution. The amount of sodium was also estimated by the activation analysis[3,4,5,6] using the reaction

$$Na^{23}(n,p)Ne^{23} \text{ with } t_{1/2} = 37 \text{ seconds and } E\gamma = 0.44 \text{ MeV}(100\%)$$

The resistivity measurement was done by a simple arrangement using a electrometer amplifier, a regulated D.C. power supply and a sample holder as shown in figure 1. The external voltage(V_{ext}) was given from the D.C. Supply of about 10V and the internal voltage(V_{int}) was shown on the electrometer. The input resistance (R_{int}) was

applied of about 10^{12} Ohms and observed on the electrometer. The Current(I) could be given by V_{int}/R_{int} or V_{ext}/R_{sample} and this way the R_{sample} can be obtained. And the resistivity(ρ) was given as

$$\rho = R_{sample}(l/A)$$

where l and A is the thickness and area of sample. In case of some of the Sodium diffused samples, the current through the sample was in the order of micrometers and so could not be measured using the electrometer in the present setup.

RESULTS AND DISCUSSIONS

The activity of Sodium obtained through activation analysis is shown in Figure 2.

This figure shows that with the increase in the number of days of dipping the Teflon sample in the sodium solution , the amount of sodium doped on Teflon sample increases. This indicates that diffusion of sodium increases when kept in contact with the Sodium solution. The results obtained on amount of Lithium or Sodium doped on Teflon is shown in Table 2 and 3 respectively. The results show that there is a change in weight which indicates that the Teflon samples do get doped by the lithium and sodium solution and the variation shows an increase in the weight with increase in number of days dipped in the solution. Further, for the lithium doped samples , the increase in weight is more for irradiated samples.

The results for the resistivity values obtained are shown in Table 4 for Lithium doped samples and Table 5 for Sodium doped samples. The results shows a decrease in resistivity for all the doped samples especially the unirradiated samples. Further, the resistivity values show a decreasing trend with increase in the doping for both Sodium and Lithium. The irradiated samples, however, show a higher resistivity than the unirradiated lithium doped samples. The pre-

Table 1: Sources of irradiation for the Teflon samples

S.No.	Source	Flux(in counts/sec/cm²)	Duration of irradiation
1.	1 MeV electrons	6E11	1 second
4.	Cf-252 neutrons	4E7	1 day

Table 2: Change in weight of Teflon sample after dipping in Lithium solution

S. No.	Sample (No. of days in the doping solution)	Initial weight in grams	Final weight in grams	Change in weight in grams	% Change in weight
1.	Doped with Lithium and not irradiated(5)	0.12964	0.14163	0.01199	9.24
2.	-do-(2)	0.12565	0.13699	0.01134	9.02
3.	Irradiated with electrons and doped with Lithium(2)	0.11978	0.13126	0.01148	9.58
4.	Doped with lithium and irradiated with electrons(2)	0.11428	0.13169	0.01741	15.23
5.	-do- (1)	0.10656	0.11912	0.01256	11.78
6.	Doped with Lithium and irradiated with Cf-252 neutrons (5)	0.10878	0.12529	0.01651	15.17
7.	-do-(2)	0.09680	0.10873	0.01193	12.32
8.	-do- (1)	0.11400	0.12768	0.01368	12

Table 3: Change in weight of Teflon sample after dipping in Sodium solution

S. No.	Sample (No. of days in the doping solution)	Initial weight in grams	Final weight in grams	Change in weight in grams	% Change in weight
1.	Unirradiated Teflon diffused in Sodium (5)	0.10494	0.13300	0.02806	26.73
2.	-do-(3)	0.10944	0.11644	0.00700	6.39
3.	Doped in sodium solution and irradiated with electrons (3)	0.11410	0.11858	0.00458	4.01
4.	-do- (2)	0.10145	0.10373	0.00228	2.24
5.	Teflon sample doped in sodium and irradiated with Cf-252 neutrons (5)	0.09540	0.12058	0.02518	26.39
6.	-do-(4)	0.09680	0.10710	0.01030	10.64
7.	-do- (2)	0.08900	0.09458	0.00558	6.26

Table 4: Resistivity of Lithium doped sample

S. No.	Sample	Resistivity in Ohm-cm
1.	Untreated Unirradiated original Teflon sample	1.5E15
12	Teflon in Lithium solution for 6 days	1.8E8
16.	Teflon sample dipped in Lithium solution for 5 days	9.9E8
17.	Teflon sample dipped in Lithium solution for 3 days	1.5E9
19.	Teflon sample dipped in Lithium solution for 2 days	1.5E9
13.	Pre irradiated with Cf252 for 300 hours and the immersed in Lithium solution	4.8E10
14.	Teflon irradiated with Cf-252 neutrons	6E10
15.	Teflon irradiated with Cf-252 neutrons for 200 hours and then kept in Lithium solution for 5 days	1.5E10
18.	Teflon sample pre-irradiated with Cf-252 neutrons and dipped in Lithium solution for 3 days	3E10

Table 5: Resistivity of sodium doped samples

S.No.	Sample	Resistivity in Ohm-cm
1.	Teflon sample in sodium solution for 4 days	5E8
2.	Teflon sample in sodium solution for 5 days	1.7e8

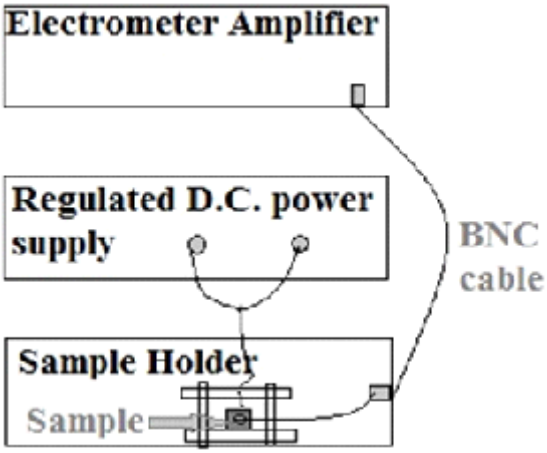

Fig. 1: Experimental arrangement for Resistivity measurement

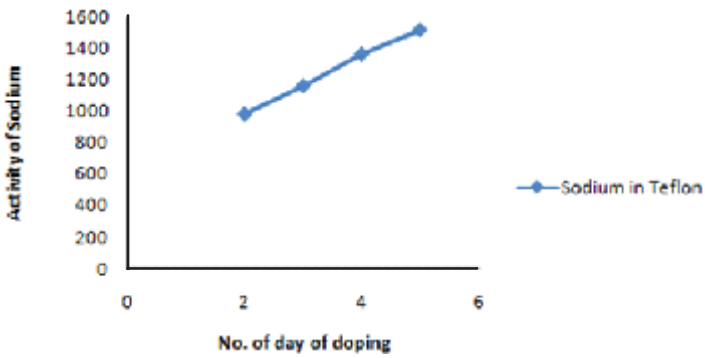

Fig. 2: Amount of sodium through activation analysis

irradiated sample shows a lower resistivity than the post-irradiated sample.

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