PREPARATION OF AMORPHOUS CARBON COMPOSITE FILMS IN POLYVINYLCHLORIDE

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Introduction

Polymer composites have wide applicability due to their unique electrical, optical and mechanical properties. These materials are very commonly used in batteries, sensors, piezoresistive gauges and electronic industry. Most of the polymers are good insulators and conductivity of the polymer composite mainly depends on the filler particles embedded in it. In these materials the electronic conduction is due to percolation of electrons in the network. The percolation is not necessarily classical in nature. In the present case the d.c. conductivity shows a scaling kind of behavior when the concentration of conducting filler (here amorphous carbon) is increased beyond a critical value known as percolation threshold [1].

Experimental

The amorphous carbon is prepared by vapor phase pyrolysis of carbon rich precursor maleic anhydride at 980^0C. A known amount of precursor is taken in a fused quartz tube closed at one end and evacuated subsequently to 0.02 Torr. Then the tube is purged with Argon gas to provide inert environment for pyrolysis. The tube is kept in a double zone furnace for 5hrs and then allowed to cool to room temperature. The precursor is kept relatively at low temperature zone and pyrolysis takes place at high temperature zone. [2] The film deposited on the inner layer of the tube is gently scratched from the surface. The film is mashed to a flake of sizeδ $5\mu\times40\mu\times40\mu$.

The broadened peak in XRD as shown in the Fig. 1 is the characteristic of amorphous nature of material. The crystallite size for this amorphous carbon is calculated as 1.76 nm. The film is highly conducting ($\sigma\sim$ 1000 S/cm) fragile and shiny.

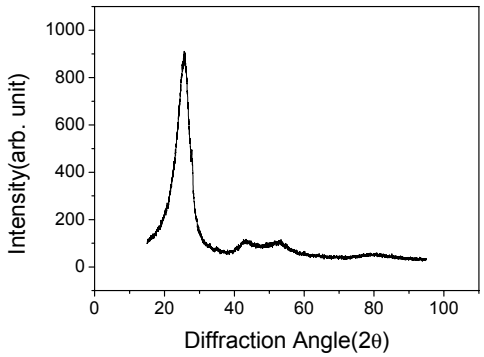

Figure-1: Powder XRD of a-C

The flakes have been mixed with Poly(Vinyl chloride) by solvent mixing method. The mixture is allowed to settle and dry in an optically flat beaker to get the composite in a form of homogeneous film of thickness 100μ. By varying the a-C (amorphous-carbon) concentration in PVC (Poly Vinyl chloride) different samples are prepared for further characterization.

Results and Discussion

Fig. 2 shows the plot of d.c conductivity versus weight percentage of the filler.

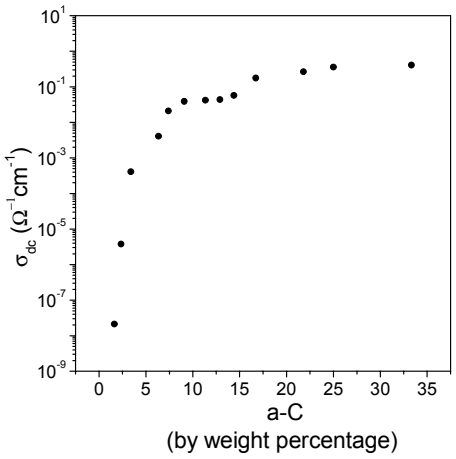

Figure-2: Conductivity Vs Percentage of a-C

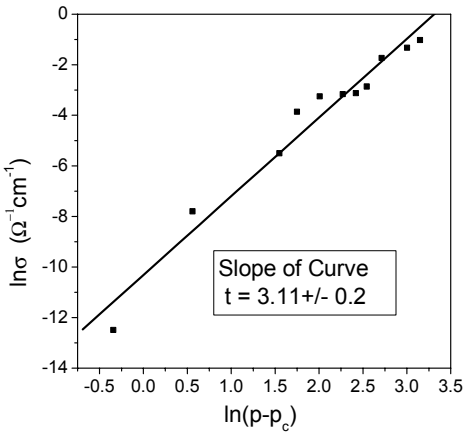

Figure-3: Lnσ Vs Ln(p-p_c)

It is found that after a minimum concentration of a-C there is steep hike in conductivity of about 6 orders of magnitude. The threshold concentration is known as percolation threshold p_c and above this concentration the d.c. conductivity follows a scaling law:

$$\sigma = \sigma_0 (p - p_c)^t \quad (1)$$

Fig.3 shows the plot of Ln σ Vs Ln $(p-p_c)$
The exponent t is known as critical exponent. By least square fitting and with the help of equation (1) we obtained p_c and t as 1.65% and 3.1 respectively. The value of t is calculated here from the slope of Fig.3. Percolation is a second order structural phase transformation. So the value of critical exponent is expected to be universal and it's accepted theoretical value for three dimensions is 2 [3]. But there are several systems that do not follow the critical exponent. In the literature the value of t has been reported from 0.55 to 6.27[3-4]. In our system the value of t is 3.1, which is within the error limit of 3, as given by mean field [5]. The effects of gaseous environment on the conductivity of the sample are under study for practical applications.

Conclusions

We have prepared a-Carbon film by the pyrolysis of carbon rich precursor such as Maleic anhydride. The XRD confirms the amorphous nature of the film. The film is mashed to powder. We prepared the composite of polymer and a-C by mixing them. The scaling behavior shown by d.c. conductivity is due to percolative behavior of electrons in composite.

References

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