Bulletin of Electrochemistry 6 (6) June 1990, pp 606–607

Preparation and characterization of polyisoprene based conducting polymer films

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The present study indicates that it is possible to obtain conducting polyisoprene, not only by I_2 doping, but also from other acceptor dopants such as $FeCl_3$, HCl, H_2SO_4 and $AlCl_3$.

Key words: Conducting polymer film, polyisoprene, characterization of polymer

INTRODUCTION

The concept of introducing nonconjugated polymer backbone for the preparation of conducting polymer [1] has facilitated the modification of a number of polymer chains. Polyisoprene has been taken as an illustrative example for verifying this concept in this paper.

EXPERIMENTAL

The commercially available rubber latex was purified as per standard procedure [2] and the conducting polyisoprene films were prepared based on methods described earlier [3].

RESULTS AND DISCUSSION

The dopants chosen for confirming the above concept belong to acceptor type [3] and the Table I lists the various types of dopants that have been employed to modify the virgin polyisoprene ($\sigma = 10^{-16}$ S.cm^{-1}) into possible conducting polymer. The doping process of polyisoprene moiety is found to have remarkable effect on the pure polysioprene film which is found to be sticky in virgin state. After the process of doping, the polyisoprene gains colouration and its transparency is considerably reduced. Moreover the flexibility of polyisoprene film is altered after the process of doping, as is evident from the easy handling of films, when compared to its virgin states and can easily be mountable. The most important characteristic change observed in this investigation is the colour variation from dark brown to yellow to pale yellow. The electrical conductivity of each polyisoprene doped film is different from another as is seen in the case of colouration and flexibility which is due to the use of different types of acceptor dopants. In majority of cases, the electrical conductivity does not reach beyond 10^{-4} S.cm^{-1} except in the case of $AlCl_3$ dopant, wherein the electrical conductivity is sensed to be around 10^{-2} S.cm^{-1}. Such enhancement of electrical conductivity of polyisoprene film clearly demonstrates that the polymer backbone possessing isolated double bond accompanied by appropriate substituent—in the present case methyl group—can be made to take part in charge transfer resulting in a conductive polymer system. The saturation of electrical conductivity level may be attributed to the

TABLE–I: Dopant concentrations and conductivities of various dopants
I Percentage of weight increase (dopant uptake)
II Conductivity

S.No.	Dopants concentration (M)	HCl I (g)	HCl II ($\times10^{-3}$ s.cm^{-1})	H_2SO_4 I (g)	H_2SO_4 II ($\times10^{-3}$ s.cm^{-1})	I_2 I (g)	I_2 II ($\times10^{-4}$ s.cm^{-1})	$AlCl_3$ I (g)	$AlCl_3$ II ($\times10^{-2}$ s.cm^{-1})	$FeCl_3.6H_2O$ I (g)	$FeCl_3.6H_2O$ II ($\times10^{-3}$ s.cm^{-1})
1.	0.1	0.24	6.35	0.33	5.90	0.83	1.90	1.0	5.06	1.90	7.05
2.	0.2	0.45	6.20	0.56	5.68	1.05	1.65	1.8	4.80	2.15	6.81
3.	0.3	0.73	6.03	0.81	5.49	1.28	1.44	2.7	4.55	2.36	6.59
4.	0.4	0.92	5.90	0.99	5.25	1.42	1.26	3.9	4.36	2.49	6.43
5.	0.5	1.10	5.82	1.17	5.03	1.58	1.05	4.5	4.17	2.62	6.20

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limitation of charge transfer over the isolated double bond net work. In the present case, the inductive effect of methyl group can enhance the electron releasing tendency of the polyisoprene backbone and with the result, a charge transfer complexation is easily favoured in the company of any electron acceptors as has now been demonstrated with I_2, $FeCl_3$, HCl, H_2SO_4 and $AlCl_3$.

Figure 1 shows the IR spectrum of doped polyisoprene which shows the decrease vibration bands due to $-C = C-$ at 1650 cm^{-1} and the additional new band at 1545 cm^{-1} supports the formation of radical cation, thereby confirming the charge transfer complex formation across the double bond of the backbone. Figure 2 shows optical absorption spectra of doped polyisoprene wherein an absorption at 400 nm confirms the coloration of doped polyisoprene film. This must be due to charge transfer excitation process [4]. Figure 3 shows the SEM photomicrograph of doped polyisoprene films showing the nonuniformity of dopant distribution. This is attributed to the isolated charge transfer process that has accompanied "doping".

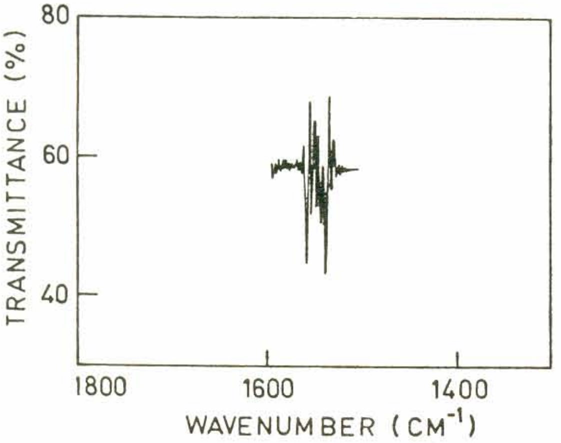

Fig. 1: IR spectrum of doped polyisoprene

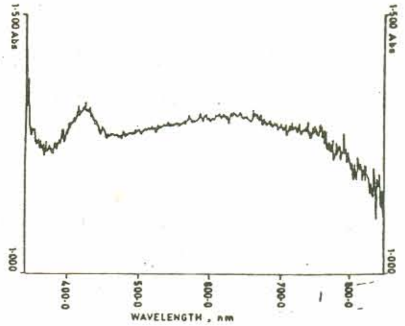

Fig. 2: UV spectrum of doped polyisoprene

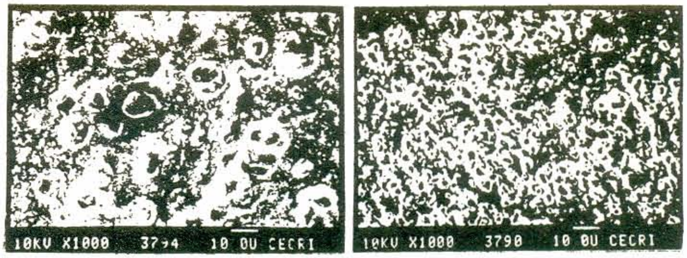

Fig. 3: SEM photomicrograph of doped polyisoprene

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