Iodine Cells: Iodine Adducts of 6-Nylon as Cathodes of Galvanic Cells

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Use of an iodine-poly(2-vinylpyridine) adduct as the cathode of a galvanic cell was reported [1]. We previously reported the use of iodine adducts of several polymers, including poly(2,5-thienylene) and poly(N-vinyl-2-pyrrolidinone) as cathodes of galvanic cells [2]. Recently we have examined the usability of other iodine-polymer adducts as the cathode and found that iodine adducts of 6-nylon, one of the most widely used polymers, serve as good cathode material for galvanic cells [3]. We report here several features of the cathode. Since the iodine adduct of 6-nylon is stable in air and can be used in the form of a film in various shapes, its handling and moulding are much easier than the iodine cathodes supported by such polymers as poly(acetylene) [4], which is unstable in air, and poly(2,5-thienylene) [2], on which is difficult to form a film either by evaporating its solution or by melting.

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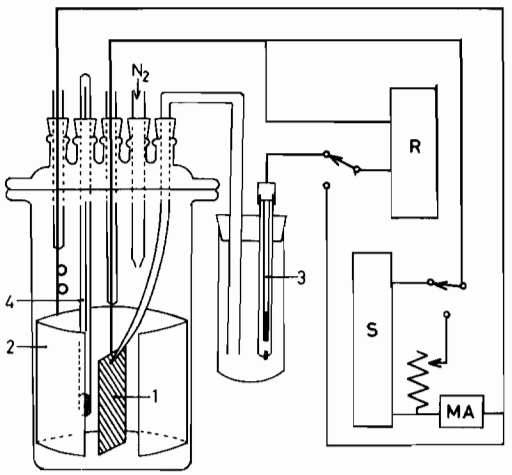

Fig. 1. Sketch of a test cell. 1: iodine-6-nylon electrode, 2: zinc electrode, 3: reference electrode (Ag/AgCl), 4: thermometer, S: galvanostat, R: recorder, and MA: milliammeter.

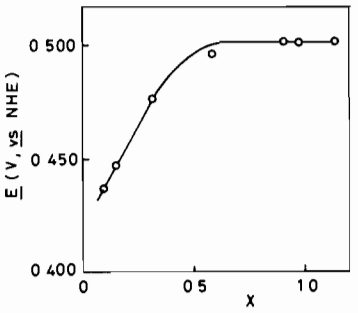

Fig. 2. Dependence of E on X (mass of iodine/mass of 6-nylon). Electrolyte = aqueous solution of ZnI_2 (1 *M*). At 25 °C.

The iodine adduct cathode was prepared by dipping a film of 6-nylon overlaid on a carbon fiber plate (Kureha carbon fiber KCF-100) into an acetone solution of iodine [5]. Under the experimental conditions the up-take of iodine by the carbon fiber plate was negligible. Figure 1 shows a sketch of an example of the test galvanic cells.

The Zn|electrolyte|iodine-6-nylon galvanic cell showed an e.m.f. of *ca.* 1.4 V (for example, 1.42 V for Zn|NH_4Cl (0.1 mol/dm^3 in H_2O)|iodine-6-nylon (mass ratio of iodine to 6-nylon = 0.27)), the value being comparable to or larger than the e.m.f. of galvanic cells with iodine adducts of other polymers [2]. Figure 2 shows dependence of potential of the iodine-6-nylon electrode, E, against normal hydrogen electrode (NHE) on the content of the iodine absorbed by 6-nylon (X = mass of iodine/mass of 6-nylon). E at small X values was considerably smaller than the standard electrode potential of the reaction $I_2 + 2e^- = 2I^-$ (ϵ^0 = 0.536 V), presumably owing to the formation of a stable iodine-6-nylon CT adduct [5]. As shown in Fig. 2 E increased with increase in X until it reached 0.502 V. When aqueous solutions of metal iodides were employed as the electrolyte solution, the plot of E against log [I^-] was a straight line with a slope of −62 mV, which roughly agrees with the value calculated according to the Nernst equation.

The discharge curves of Zn|ZnI_2(aq)|iodine-6-nylon cells are shown in Fig. 3. The initial E was fairly stable when X was larger than 0.35; after discharging *ca.* 380 C per gramme of iodine (*ca.* 9.7 × 10^4 C per mole of I_2) it dropped steeply. When the iodine-6-nylon adduct with X value of 0.937 was employed the Zn|ZnI_2(aq)|iodine-6-nylon galvanic cell had an energy density of 58 Wh/kg based on the weights of the iodine-6-nylon adduct and Zn consumed. A thin disk-type Zn|ZnI_2(aq)|iodine-6-nylon

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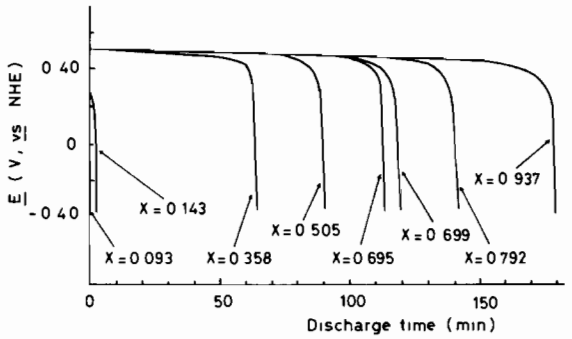

Fig. 3. Discharge curves. 6-nylon = 30 mg. Electrolyte = aqueous solution of ZnI_2 (1 *M*). At 25 °C. Discharged at constant electric current (1 mA).

cell can be easily prepared, and the galvanic cell can be used to light an electric lamp for more than 10 h and to rotate a propeller by an electric motor.

The present $Zn|ZnI_2(aq)|$iodine-6-nylon cell can be applied to a secondary cell, which shows an e.m.f. of *ca.* 1.4 V.

References

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