A Corrosion Study of Stainless Steels in Ionic Liquids

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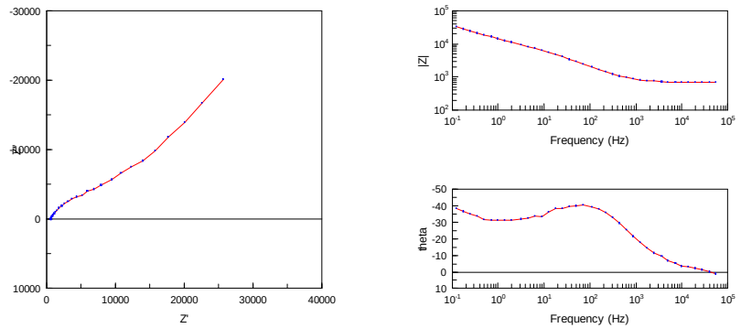
In this era of 'green chemistry' ionic liquids give a new route to reducing waste in both industrial and academic sectors.[1] An ionic liquid is defined as a solution consisting entirely of ions. Therefore as electrochemists these new solvents lead to exciting new opportunities, as no supporting electrolyte is required to promote current flow.
Ionic liquids are cheap and easily prepared, have effectively no vapour pressure, and are remarkable solvents for both organic and inorganic molecules promoting a diverse research area. Their most important property to an electrochemist is the fact that they have an electrochemical window of 4V, giving an automatic advantage over more traditional solvents (e.g. H_2O).[2]

The corrosive ability of three ionic liquids has been investigated: 1-butyl-3-methylimidazolium hexafluorophosphate ([bmim][PF_6]); 1-butyl-3-methylimidazolium nitrate ([bmim] [NO_3]); and 1-butyl-3-methyimidazolium bis(trifluoromethylsulfonyl)imide ([bmim][NTF_2]). Seven industrial grade stainless steels have been tested: aisi 304; aisi 310; aisi 316; aisi 321; aisi 347; 15-7PH; 17-7PH.

Five different methods of evaluation were used: o*pen circuit analysis; cyclic voltammetry; general corrosion (Rp); pitting corrosion; and electrochemical impedance spectroscopy.* The different corrosive abilities of the ionic liquids will be discussed, along with the corrosion rates of individual stainless steel types in particular ionic liquids where composition of the various stainless steels has been considered.

Tafel and 2nd Stern methods were used to analyse the data from cyclic voltammetry, general corrosion, and pitting corrosion runs. Electrochemical impedance spectroscopy data was obtained in complex plane mode, which was converted to bode diagrams. The equivalent circuit was then fitted to the data obtained.

These results have been verified by Scanning Electron Microscopy, where this technique was carried out on stainless steel samples before and after exposure to the ionic liquid. A few examples of this area will be shown.



a) Complex Plane b)BodeDiagrams

Fig. 1: Impedance data: a) Complex plane and b) Bode diagrams of SS aisi 321 in [bmim][PF_6]

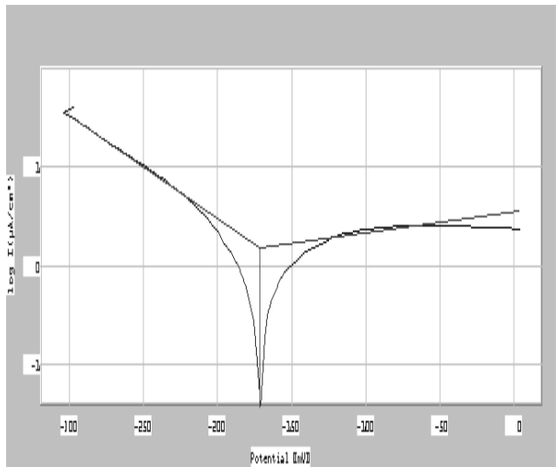


Fig. 2: Cyclic Voltammetry Tafel analysis of SS 17-7PH in [bmim][NTF_2]

References:

1. K. R. Seddon, J. Chem. Tech. Biotechnol:351 (1997).
2. Y. I. Rika Hagiwara, Journal of Fluorine Chemistry 105:221 (200).

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