Entrapment of Organic Molecules within Metals.
2. Polymers in Silver

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We describe a new type of composite material: polymers entrapped within a metal. Polystyrene-sulfonic acid and poly(vinyl alcohol) were entrapped within silver. Detailed procedures for the entrapment are provided, and it is shown that this entrapment is a distinctly different process from polymer adsorption on the metal surface. Characterization of these new composites includes XRD measurements, SEM with EDAX, surface area, porosity, and density measurements, and full oxidative degradation analysis by thermogravimetry (TGA/DTA/DTG) coupled to mass spectrometry. A pronounced effect of the metal caging on the thermal degradation of the two entrapped polymers was observed. On the basis of all experimental observations a proposition is made as to the molecular level picture of the entrapment.

1. Introduction

In a recent publication1 we described a new family of materials, namely organically doped bulk metals. Surprising as this may sound, although organically doped polymers and inorganic materials (e.g., porous sol-gel matrices2,3 and inorganic crystals4) have been known for decades, the doping of metals seems to have been unexplored.5 Judging from the many useful properties that have been induced into the organic and inorganic materials by the incorporation of suitable dopant molecules,2,6,8 and judging from the observations of interesting and useful effects induced by the matrix on dopant properties,7 one can envisage the potential of similar fruitful applications by the merging of the properties of metals with those of organic molecules. Indeed, while only ~90 metals are known, there are more than 20 million reported organic molecules, and hence the library of properties which in principle can be induced in metals by the organic dopant, and in the dopant molecules by the metal environment, is enormous.

Whereas our first report1 dealt with the entrapment of small molecules in a metal, here we focus on the entrapment of polymers. The motivation has been the highly successful merging of organic and inorganic polymers—a huge field by itself—which has led to many new materials, and suffices it to mention as a typical sub-field the organic-polymer modified sol-gel materials.6,8 Of course, metals and organic polymers have appeared in the same context in various applications, such as in colloidal metals dispersed in polymeric thin films,9 polymer coatings of metals,10 surface metallization of polymer surfaces,11 polymeric particles doped with metals,12 and more, but not, to the best of our knowledge, in the context of direct doping during synthesis of the metal. Here we describe how to do it with polymers.

Specifically, we demonstrate the feasibility of obtaining such materials by the doping of silver with poly(4-styrene sulfonic acid) (PSSA) and with poly(vinyl alcohol) (PVA).

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