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Corrosion Behavior of Co-Polyacetal Resin in Nitric Acid Solutions

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Abstract

We investigated the corrosion behavior of Co-polyacetal (Co-POM) in nitric acid (HNO_3) solution and evaluated the degree of degradation by following the changes in weight, dimension, color, flexural strength, and molecular weight. After immersion, the surface of the specimens changed from white to yellow. The specimen weight in HNO_3 solution decreased after an incubation period. When the specimens immersed in distilled water were dried, the flexural strength recovered to nearly its initial value; however, this was not observed for specimens that were immersed in HNO_3 solution and then dried. From size exclusion chromatography measurements, it was observed that the degradation of Co-POM by the HNO_3 solution was limited to near the surface of the specimen, whereas the interior had remained nearly intact. The corrosion rate was calculated from the thickness of the corrosion layer, and the residual thickness of the uncorroded layer and the flexural strength after immersion could be predicted according to the estimated corrosion rate. From this study, it was inferred that the degradation of Co-POM by HNO_3 solutions is of the corroded layer-forming type.

Key-words: *Co-polyacetal resin, Electric discharge, Corrosion, Hydrolysis, Nitric acid*

1. Introduction

It is well known that polymeric insulation materials deteriorate when exposed to corona discharge and its byproducts such as active oxygen, ozone (O_3), and nitric acid (HNO_3) produced by the reaction between NO_X and H_2O[1-3]. To prevent accidents with high-voltage apparatus, the deterioration of polymeric materials has been globally researched for over a hundred years using electrical diagnostics. However, almost all of these experiments are electrical in nature, and the corrosion mechanism and its forming rate on an insulating polymer are not well known.

The degradation of polymeric materials can be classified as physical (e.g., swelling), chemical (e.g., hydrolysis and oxidation) or both[4]. Changes in specimen appearance, weight, and mechanical properties have been investigated to understand the mechanism behind chemical deterioration and corrosion[5-9]. For thermosetting polymers, the corrosion mechanism could be classified as (1) surface reaction type, (2) corrosion layer-forming type, and (3) penetration type[10,11]. Determining the corrosion behavior of polymeric materials is necessary for predicting the residual life and improving the design techniques of industrial equipment and their components.

The authors have examined the resistance of Co-polyacetal resin (Co-POM), which is one of the major building blocks of electrostatic atomizers, to solvents and the by-products from electro discharge[12-16]. POM resin is synthesized from formaldehyde and has two polymer types: the first is a homopolymer, which was industrialized by DuPont in 1960; the second is a copolymer, which is used in chemical, electrical, and automobile industries because of its excellent chemical endurance, mechanical strength, and workability[17]. However, Co-POM is hydrolyzed by acid, thus limiting its use to only a few selected industrial fields.

Recently, application products using corona discharge have found use in several fields[18] and some of them such as the electrostatic atomizer[19] as well as copiers and printers are widely used in the color material field. Predicting the useful lifetime of polymeric materials by investigating their corrosion behavior is critical in many industrial applications. In this paper, the corrosion behavior of Co-POM in HNO_3 solution was studied, and the flexural strength of Co-POM during exposure was predicted.

2. Experimental

2.1 Material

The material properties of the base polymer used in this study are listed in **Table 1**. Specimens were produced from commercial Co-POM (NC) round rods (NIPPON POLYPENCO Ltd.). The specimens for the immersion tests were machined to plates of 60 × 25 × 2 mm. Before the immersion test, the specimens were dried in a thermostat chamber at 50 ℃ until