"Characterization of PA-11 Flexible Pipe Liner Aging in the Laboratory and in Field Environments Throughout the World"

ARTHUR JAETON GLOVER

College of William & Mary, Department of Applied Science, 2010
Field: Polymer Science, Degree: PhD

Advisor: David E. Kranbuehl, Professor of Chemistry

Abstract

Polyamide-11 (PA11) is a polymer of the Nylon family whose monomer is obtained from the castor bean, a renewable resource. It is widely used in offshore oil and gas production as a non-rigid flexible pipe liner, allowing for oil and gas transport from the wellhead to floating platforms for processing. The degradation of PA11 over time may lead to the pipe's failure, with possibly catastrophic results which include loss of life. Until now, the characterization of the degredative process has been limited to laboratory studies of the effects of water and temperature on the rate and degree of hydrolysis. In this dissertation, a more exact model than those proposed in the literature thus far is defined and used to quantify the effects of temperature on the rate and degree of PA11 hydrolysis. This is performed using accelerated aging experiments in the lab which are evaluated by a primary means of molecular weight determination, size exclusion chromatography - multiple angle laser light scattering (SEC-MALLS). The effects of methanol and ethanol, used in the industry to control solid hydrate formation, are then characterized with respect to concentration and temperature, a topic which has not yet been addressed in the literature. Also novel to this work is the discovery of the effects of acetic acid, valeric acid, and 3-cyclopropionic acid on the rate and degree of PA11 hydrolysis. While these acids are present in the offshore oil and gas environment, acetic acid is the most common, and has been identified as a serious factor affecting degradation. The effects of acetic acid on rate and degree of hydrolysis are incorporated into the temperature dependence described above, and adapted to a model well suited for characterizing the degradation of PA11 in the changing temperature environments found in the field. By characterizing coupons removed from PA11 pipes in oil production fields in various parts of the world, the model is tested and used to predict aging of PA11 pipe. The model is shown to be effective at predicting degredation for times greater than ten years, which has never before been described. The effects of annealing coupled with decline in molecular weight on PA11 mechanical properties in accelerated aging experiments versus aging in the field environment is discussed. These contributions to understand and predict the aging of PA11 flexible pipes are central to increasing the safety of offshore oil and gas production, a topic that today is vastly important.