Modeling of Degradation of Plastic Materials under Local Climate Conditions and Artificial Climate

A thesis submitted to the Faculty of Science,
University of Colombo
for the Degree of Doctor of Philosophy

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April 2016

Abstract

Consumption level of plastic has increased during the last few decades due to urbanization and industrialization in Sri Lanka. Even though plastic has facilitated easy and a comfortable life, liberation of its ingredients (non polymeric substances NPS) change bio diversity. It accumulates in the ecosystem which becomes a health hazard to animals and human. Moreover, plastic strength is reduced due to liberation of additives resulting degradation of plastic which is important for manufacturing, recycling and construction industries.

This research is focused on to develop mathematical models based on weight loss, toughness, MFI, density, tensile at different temperatures to study the plastic degradation. The changes of stress-strain behavior and mechanical properties of plastic depend on the number of days exposed to heating at day and cooling at night in the natural environment. Kinetics of degradation, mechanical and physical properties predict the level of degradation. Among the mechanical properties, toughness is selected as one of the indicators to predict degradation.

Standard size dumbbell shape samples, 4×3 mm rectangular shape plastic sheets and 1.5 × 2 mm rectangular shape samples were kept in artificial conditions and natural condition. The artificial conditions 80°C, 100°C, 120°C and 140°C temperatures were set. In the artificial conditions heating and cooling cycles were set to 8 hours for heating at these specified temperatures and air cooling overnight at ambient temperature. This process simulated the natural environmental heating and cooling condition. Physical and mechanical properties were determined both under artificial conditions and natural condition.

Toughness of each sample was calculated in two different ways, in one method it was calculated using regression equation based on selected stress values of strains. Matching ratio of toughness (β) was defined as a new index to determine the ratio of toughness. The percentage of the retention of plastic behavior (RPB%) of commercial plastic product was

defined as a new index to predict plastic limit. It could be calculated when the matching ratio of toughness (β)was known. The proposed model could be utilized to calculate the retention of plastic behavior (RPB%) as a percentage with respect to the original state under natural condition. Degradation was predicted by utilizing matching ratio (β) and the percentage of relative deference of matching ratios (γ%).

Kinetic model was developed for very low extent of weight loss (0.3% by mass) at isothermal conditions in the range of temperature 80°C to 140°C, has significantly affected the mechanical and physical properties. Activation energy, instantaneous energy, order of reaction and frequency factor were calculated by using the developed model for three different ranges of 0-0.4, 0.4-0.6 and 0.6-0.99 weight losses and developed model expressed in terms of the temperature and time dependent parameters.