

Degradation of plastic toys without electronic devices

Samuel Díaz¹, Georgina Fernández¹, Landy Ramírez², Francisco Pérez¹

¹Department of Engineering, National Autonomous University of Mexico, Mexico City, 04510, Mexico

²Department of Chemistry, National Autonomous University of Mexico, Mexico City, 04510, Mexico

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Presenting author email: sdiaz.jaimes@comunidad.unam.mx

Introduction

The manufacture of plastic toys has been on the rise since the 1950s thanks to their flexibility, hardness, resistance and malleability present in them compared to traditional toys.

However, the slow degradation of plastic toys from municipal solid waste landfills has caused their accumulation in the natural and aquatic environment (Achilias, 2007). The consequences of plastic waste in the environment have been: the impact on fauna, the uncontrolled combustion of plastic waste and the slow degradation.

Fauna commonly confuse waste with food or become trapped and present asphyxia, lacerations, infections, decreased reproduction and mortality (Cho, 2009; Waluda & Staniland, 2013; UNEP-NOAA, 2012; Li, Tse, & Fok, 2016). The uncontrolled combustion of plastic waste and, in particular, of those containing halogens such as PVC, polytetrafluoroethylene / Teflon, heavy metals, brominated flame retardants, can lead to emissions of hazardous substances, acid gases and pollution by unintentional persistent organic pollutants (POPs) such as dioxins (UNEP, 2015). Although no one knows for sure, the degradation of plastics can last up to 300 years. Aging tests have not been carried out for the particular case of toys.

For this reason, it was decided to carry out the degradation tests of plastic toys without electronic devices in four types of toys: superhero-type dolls, wrestler dolls, baby dolls and dolls, using an accelerated weathering chamber.

Methodology

The toys that were analyzed to determine their degradation are shown in Figure 1. Their dimensions and weight were used as control parameters. The identification of the plastics that make up the toys was carried out with the help of a Perkin Elmer Spectrum Two model FTIR-UATR spectrophotometer. However, the spectra of each toy presented other compounds or additives, that is, plastics are not made up of just one polymer.



Figure 1. Plastic toys analyzed: A) superhero dolls, B) baby dolls, C) doll, and D) wrestler dolls

The methods used in this work to test the loss of physical properties of plastics were taken from the international standard used in general for accelerated weathering chamber tests, ASTM G151 and ASTM G154, which establishes that plastics must be placed in triplicate and maximum and minimum conditions of temperature and humidity of the climatological conditions of the study area, as well as the simulation of solar radiation by means of an ultraviolet fluorescent lamp with a wavelength of 340 nm.

The toys were randomly placed inside the weathering chamber and the weather conditions (maximum and minimum temperature, maximum and minimum humidity, and ultraviolet radiation) of the municipality of Colón, Querétaro for a simulated period of time of 219 hours equivalent to 3 years.

The characteristics of the toys are mentioned in table 1.

Table 1. Physical characteristics of the toys before the tests.

Toy	Type of polymer	Mass (g)	Height (cm)	Long (cm)	Width (cm)	Thickness (mm)
Superhero 1	SAN	194	30	9.5	4	1
Superhero 2	SAN	140	30	9.5	4	1
Wrestler 1	PE	20	10	7.5	3	15
Wrestler 2	PE	20	10	7.5	3	15
Wrestler 3	PE	22	10	7.5	3	15
Baby doll 1	PVC	478	35	21.5	10	1
Baby doll 2	PVC	300	30	14	8.5	1
Baby doll 3	PVC	242	30	13	7.5	1
Doll 1	PVC y ABS	122	30	6.5	3	1
Doll 2	PVC y ABS	118	30	6	3	1
Doll 3	PVC y ABS	126	30	6.5	3.5	1

Results and conclusions

Upon completion of the accelerated weathering chamber tests, the toys were reweighed and measured. The only ones who presented a difference between the weight at the beginning and at the end of the test were the wrestlers and the baby dolls. The others maintained their same weight and dimensions.

In the case of the wrestler dolls, only 2 increased their weight by 1% caused by the expansion of the plastic, despite the fact that the type of plastic is rigid.

Two of the baby dolls decreased their weight by 1.6 and 0.6% respectively. This could be due to the fact that one of them had a strong aroma, characteristic of PVC plasticizer additives. The structure of PVC is too rigid and must contain a good amount of this additive to achieve its flexibility.

The superheroes and dolls are made with a more rigid plastic and with better additives that allow the resistance to degradation of the toys in the accelerated weathering chamber, the conditions of humidity, temperature and solar radiation could have a greater effect with a longer time dragged on.

Considering the above, it is concluded that the degradation of this type of toys will take a long time and will harm the environment. It could be recommended that a management plan be drawn up for toys with these characteristics, where manufacturers can implement a circular economy in the recovery of toys and reuse them to make new ones, or failing that, other companies can process their products with the same discarded toys.

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