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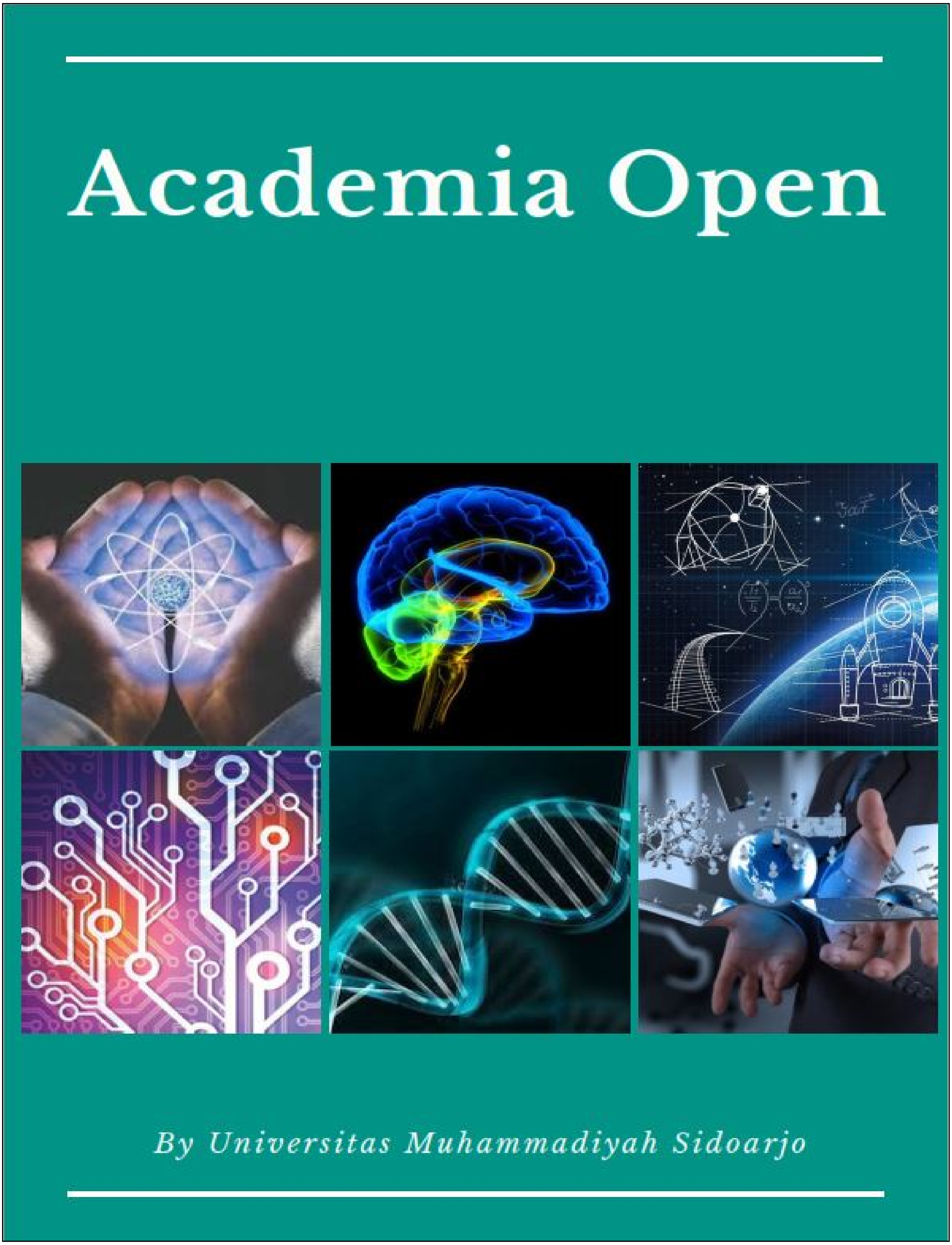
Academia Open
By Universitas Muhammadiyah Sidoarjo

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Treatment Increasing the Strength of Polymer Materials

Perawatan Meningkatkan Kekuatan Bahan Polimer

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Abstract

This study investigates the pivotal role of PE carbonyl groups in light resistance, with a focus on their impact during different stages of aging. Through the application of mechanochemical destruction, hydroperoxides are formed as initiators of photoaging in PE. Our findings reveal the superior effectiveness of hydroperoxides in early aging stages, while the presence of carbonyl groups exerts significant influence in later stages. The results emphasize the dual mechanisms driving photoaging in PE and provide valuable insights for developing strategies to enhance its durability and longevity.

Highlights:

- The presence of carbonyl groups in polyethylene determines its resistance to light.
- Hydroperoxides formed during mechanochemical destruction initiate photoaging in polyethylene.
- Carbonyl groups play a significant role in the later stages of polyethylene photoaging.

Keywords: Polyethylene, photoaging, carbonyl groups, hydroperoxides, light resistance.

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Introduction

Since the formation of the Earth more than 4 billion years ago, elements such as carbon, hydrogen, oxygen and nitrogen have been combined into complex molecules in its giant “laboratory”. Once this led to the emergence of the most mysterious process called life, the material basis of the origin of which was a polymer. This polymer - protein - is synthesized in nature from simple chemical compounds: methane, ammonia and carbon dioxide. This is how life was born, and one of its forms, as a result of centuries of development, became "human". That is why almost the entire human body consists of the same polymer. At the same time, there were other natural forms of polymers, such as wood, cotton, cellulose, starch, and others, which were subsequently used by man. In the fifteenth century, Christopher Columbus noticed that the Indians of South America used in their games a certain solid mass obtained from the milky juice of a tree, which they called "weeping." Playing with this solid object, they could not even imagine that its material, later called rubber, would become the basis for a powerful industry that would bring huge profits. Some "accidents" also contributed to the development of polymer science. In the nineteenth century, "gun clap" - a nitro derivative of ordinary polymer cellulose and "celluloid" were discovered quite by accident. Meanwhile, nineteenth-century explorers encountered inexplicable difficulties when working with certain chemicals. Sometimes reactions with such substances resulted in the formation of sticky and viscous materials that adhered to the walls of test tubes and clogged the valves of chemical glassware. And only the genius of Leo Bakkeland helped to understand that a new branch of chemistry would grow out of these sticky test tubes and that these unusual materials would soon open the doors of a huge technological treasury. From phenol and formaldehyde, he creates a resin (bakelite) that can be molded into a solid non-combustible product. Bakelite was the forerunner of many other modern synthetic polymers. Jean Brandenburger invented the famous cellophane.

Main part

Around the same decade, new polymers with constantly improving properties began to appear from scientific laboratories around the world. Obviously, polymers were not discovered all of a sudden. It is the fruit of the hard work of many energetic scientists whose work has so enriched human life. Today, our knowledge of polymer science and technology is so deep that an experimental scientist can create an almost unlimited range of new materials. Of all the plastics produced, 41% is used in packaging, of which 47% is spent on food packaging. Convenience and safety, low price and high aesthetics are the defining conditions for the accelerated growth in the use of plastics in the manufacture of packaging. Packaging made of synthetic polymers, which makes up 40% of household waste, is practically "eternal" - it does not decompose. Therefore, the use of plastic packaging is associated with the generation of waste in the amount of 40...50 kg/year per person. The choice of technological parameters for the processing of software waste and the areas of use of the products obtained from them is due to their physicochemical, mechanical and technological properties, which differ to a large extent from the same characteristics of the primary polymer. The main features of recycled LDPE (VLDPE), which determine the specifics of its processing, include: low bulk density; features of the rheological behavior of the melt, due to the high content of gel; increased chemical activity due to structural changes occurring during the processing of the primary polymer and the operation of products obtained from it. In the process of processing and operation, the material is subjected to mechanochemical influences, thermal, thermal and photo-oxidative degradation, which leads to the appearance of active groups, which, during subsequent processing, are capable of initiating oxidation reactions [1]. The change in the chemical structure begins already in the process of primary processing of software, in particular during extrusion, when the polymer is subjected to significant thermal-oxidative and mechanochemical effects. The greatest contribution to the changes occurring during operation is made by photochemical processes. These changes are irreversible, while the physical and mechanical properties, for example, of a polyethylene film that has served for one or two seasons to cover greenhouses, are almost completely restored after overpressing and extrusion [2]. The formation of a significant number of carbonyl groups in the PE film during its operation leads to an increased ability of VLDPE to absorb oxygen, resulting in the formation of vinyl and vinylidene groups in the secondary raw material, which significantly reduce the thermal-oxidative stability of the polymer during subsequent processing, initiate the process of photoaging of such materials and products from them reduce their service life. The presence of carbonyl groups does not determine either the mechanical properties (their introduction of up to 9% into the initial macromolecule does not have a significant effect on the mechanical properties of the material), nor the transmission of sunlight by the film (the absorption of light by carbonyl groups lies in the wavelength region of less than 280 nm, and the light of such a composition practically not contained in the solar spectrum) [3]. However, it is the presence of carbonyl groups in PE that determines its very important property - resistance to light. The initiator of photoaging of PE are hydroperoxides, which are formed during the processing of the primary material in the process of mechanochemical destruction. Their initiating action is especially effective in the early stages of aging, while carbonyl groups have a significant effect in the later stages. As is known, competing reactions of destruction and structuring occur during aging. The consequence of the first is the formation of low molecular weight products, the second is the formation of insoluble gel fraction. The rate of formation of low molecular weight products is maximum at the beginning of aging. This period is characterized by a low gel content and a decrease in physical and mechanical properties. Further, the rate of formation of low molecular weight products decreases, a sharp increase in the content of the gel and a decrease in the relative elongation are observed, which indicates the course of the structuring process.

Conclusion

Then (after reaching the maximum), the gel content in the VPE decreases during its photoaging, which coincides with the complete consumption of vinylidene groups in the polymer and the achievement of the maximum allowable values of relative elongation. This effect is explained by the involvement of the resulting spatial structures in the process of destruction, as well as cracking along the border of morphological formations, which leads to a decrease in physical and mechanical characteristics and a deterioration in optical properties.

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