

University of Belgrade
Technical Faculty Bor

PROCEEDINGS

XXIII International Conference Ecological Truth

Editors

Radoje V. Pantovic

Zoran S. Marković

EcoIst '15

Hotel "PUTNIK", Kopaonik, SERBIA
17-20 June 2015

UNIVERSITY OF BELGRADE
TECHNICAL FACULTY BOR



**XXIII International Conference
"ECOLOGICAL TRUTH"**

Eco-Ist'15

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**Radoje V. PANTOVIC
and
Zoran S. MARKOVIC**

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**THE IMPACT OF THE PRODUCTION AND USE OF POLYVINYL
CHLORIDE ON THE ENVIRONMENT**

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ABSTRACT

The paper presents the most important characteristics of polyvinyl chloride (PVC), the types of additives that are added to it to improve its properties (primarily mechanical) and its field of application. Particular emphasis is placed to how the process of production of PVC and its application affect to the environment as well as protection measures. Bearing in mind that the environment is more hazardous, is now a serious attention is paid to recycling which can be used plastic waste and thereby also reduce environmental pollution.

Key words: polyvinyl chloride, environmental protection, recycling.

INTRODUCTION

Polyvinyl chloride is more than 70 years one of the most important polymers, whose production capacity is about 20% of the total world production of polymers. Its application is extremely broad which results in the presence of large amounts of PVC waste. Therefore, serious attention is given to the rehabilitation of such waste in order to protect the environment. Environmental protection includes: preservation of clean air, land and water, removing the waste material, noise and radiation protection, use of resources, cultivating sources and so on. [1]. In the Republic of Serbia in 2009. brought the Law about waste management, which regulates the following: type and classification the waste material, planning and operators of waste management, the responsibilities and obligations of waste management, financing the waste management etc. [2]. Recycling is the set of activities which ensure the re-use of waste materials. By recycling is achieved saving of raw resources (all materials origin from the nature and has limited quantities), saving energy (no energy loss in the primary processes, as well as in transport which following that processes, and additional energy is obtained by burning materials that are not recycled), environmental protection (waste materials degrade living environment, and it is protecting by recycling) and creation of a new jobs (processes in the recycling of materials includes investment of knowledge and work, which creates the need for new working places) [1].

POLYVINYL CHLORIDE (PVC)

In the procedure of polymerization the vinyl chloride, obtained the powder from which by further processing of products we get two types of PVC: rigid PVC and soft (flexible) PVC. Rigid PVC is obtained by processing the polymer powder without special additives. It is transparent, hard, tough and difficult for processing, but very stable on the influence of atmospheric precipitation, humidity and chemicals. It is used, for example, for making window frames, casing boxes, etc. Soft PVC is obtained by processing the polymer powder with the addition of plastificators from whose share depending by its properties, also. It has weaker mechanical properties, less resistant to heat, precipitation and chemicals, compared to the hard PVC, but is more flexible, elastic and it is easier for processing. It is used for making insulators for cables, medical instruments disposable, tubes, gloves, etc. Soft PVC is transparent, and can be used to make transparent bottles and foils. Generally, it can be said that the properties of polymers are determined by their internal structure, and some of their properties are the similar like characteristics of solid crystalline bodies, while some are similar characteristics to liquids [3]. Physical and mechanical properties of hard and soft PVC and are shown in Table 1. [4, 5].

Table 1. Physical and mechanical properties of PVC

Property	Unit	Rigid PVC	Soft PVC
<i>Density</i>	g/cm ³	1,38-1,55	1,16-1,35
<i>Tensile strength</i>	MPa	40-60	10-25
<i>Extension at break</i>	%	30-70	250-450
<i>Compressive strength</i>	MPa	55-90	6-12
<i>Shore hardness</i>	-	D 65-85	A 40-100
<i>Specific heat capacity</i>	J/K g	0,8-1,1	1,3-2
<i>Thermal conductivity</i>	W/Kcm	(15-20)x10 ⁻⁴	(13-17)x10 ⁻⁴
<i>Coefficient of thermal expansion</i>	1/K	(5-10)x10 ⁻⁵	(7-25)x10 ⁻⁵
<i>Temp. of continuous use</i>	°C	65-85	50-70

Production of PVC is big, because of good mechanical and physical properties, as well as a numerous variety of application possibilities. PVC is a nonflammable, burning only in the presence of a flame and is chemically inert. Because it contains chlorine, a melting point of PVC is very high (100-260 ° C) so, in the case of fire, has the characteristic of self-extinguishing. PVC is easily decomposed at very high temperatures producing hydrochloric acid and corrosive gas. It is compatible with many additives, including fillers, plasticizers, stabilizers, lubricants, pigments, and other polymers. Figure 1 shows the share of certain additives to PVC [6]. These additives make possible to process more easily by various techniques and to obtain products with even better mechanical properties [7, 8].

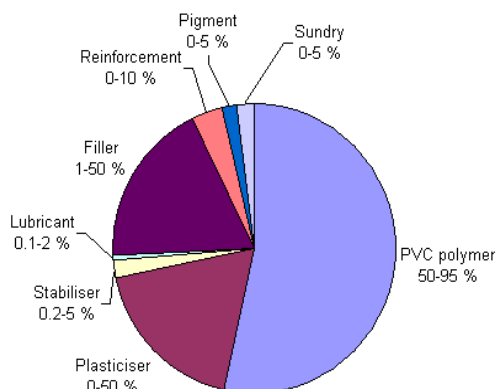


Figure 1. Proportion of certain additives in PVC mixture

During the production of PVC are formed dioxins which are among the most toxic chemical compounds, and ethylene dichloride or vinyl chloride which are in the form of gases and through the waste water discharge into the environment. Dioxins are formed as unwanted by-products, also in many other industrial processes that use chlorine, such as the production of chemicals and pesticides, bleaching of pulp and paper, and waste incineration. These are highly toxic substances in the environment, which are natural processes almost intact. Dioxins are organic compounds belonging to the group of polycyclic aromatic hydrocarbons (polychlorinated dibenzo-p-dioxins PCDD) with similar physical and chemical properties. PCDD include 75 different isomers of which the most dangerous is 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (TCDD), or simply "dioxin" [9]. The main problem in the life cycle of PVC from the manufacturing process, to the recycling process is formation the dioxine.

RECYCLING OF PLASTICS AND PVC AND PROTECTION MEASURES

Successful recycling of plastic waste began in the moment when it is developed the method for separating different polymers from mixture. Today, the research in the field of processing of waste materials is very well developed, which contributed to reducing the level of pollution of the environment. The process of recycling the waste by different composition in recent years is the most developed in Japan, by designing machines that can process it. At the beginning of 1975., in Japan was more than 20 factories, whose production capacity, annually, was approximately 40.000 tons of finished products. These products are used as a substitute for wood and concrete, because they are cheap, resistant to the high temperatures, atmospheric precipitation etc. In order to successfully processed such a waste material, it is necessary to contain 80% of the thermoplastic (PVC, polyethylene, polystyrene, nylon, etc.), and the rest may be paper, aluminum foil, sand, etc. [10]. To the recycled material, in a certain percentage can be added the new non-recycled materials, and then it can be re-processed resulting in a lower price of a definitive product. PVC waste can be treated in three ways: by recycling, incineration and storage in dumps. PVC waste can be successfully recycled;

recycling mark is 3, Figure 2. Burning must be strictly controlled due to the release of toxic substances. Disposal in landfills is the least acceptable, because PVC is not naturally degraded, so that eventually formed large deposits which is not good for the environment. However, regardless the existing difficulties in terms of PVC waste remediation, the main reasons for its wide range of applications are quality and saving energy and raw materials. For the production of PVC it is necessary 20% less energy than for the production of other types of plastic. Also, the raw material for PVC is chlorine, which is obtained by processing ordinary salt (60%). PVC is considered as material that is difficult and expensive to recycle, but the advent of new technologies solved this problem successfully. As the example of recycling PVC in Figure 2, is given a closed cycle of recycling PVC window profiles [11].



Figure 2. The cycle of recycling PVC window profiles

In order to avoid a negative impact on the environment in the complete processing of PVC we take care about additives that are added. Thus, for example, in the production of window profiles, instead of lead-based stabilizers in practice are increasingly using stabilizers based on calcium and zinc [12]. The application of new and modern technologies in the process of recycling waste plastics can reduce the level of release of toxic substances. The best example is the company "Envion" from Washington, which is operating in Maryland and converts waste plastics into synthetic oil. This technological process does not even require prior separation of plastics by type and origin [13]. Time of degradation the waste plastics is 100-1000 years. Because of that, it is necessary to implement a measure of collecting plastic separately from other waste [1]. Within the framework of regulations and planning documents of the EU, increasingly promote waste reduction, which would reduce the waste problem at the source. There is, however, a significant difference in the application of this principle in EU member states. The percentage of waste recycling ranges from 10 to 65%, and the

percentage of waste disposal to landfill from 10% to 90%. The principle of reducing the amount of waste includes initiatives for the introduction of cleaner technology and comprehensive campaign to raise public awareness among the population. EU policy about waste material emphasizes the development of measures such as the promotion of cleaner production, removal of hazardous characteristics of waste treatment, the establishment of technical standards to limit the content of certain hazardous substances in products, promoting re-use and recycling of waste, the use of economic instruments, analysis of the product life cycle, development of eco-labeling system [14]. The implementation of environmental policy is based on the precautionary principle and the principle of prevention. Each activity must be planned and implemented in a manner that causes the least possible change in the environment and the least risk to the environment and human and animal health reduce the load space and consumption of raw materials and energy in construction, production, distribution and use [14].



CONCLUSION

Environmental protection is a priority task in all countries and is directly related to the degree of development of the national economy. Also, the ongoing education of the population on the importance of a healthy environment contributes to its preservation. The development of new materials and their use imposed by the question how to manage the waste generated with their processing and use. PVC is a polymer of which the production capacity and the use of constantly increasing. PVC waste can be treated in three ways: by recycling (most used), burning (must be strictly controlled due to the release of toxic substances) and stored in dumps (minimum acceptable because PVC is not naturally degraded, so that eventually formed large deposits)

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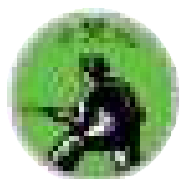


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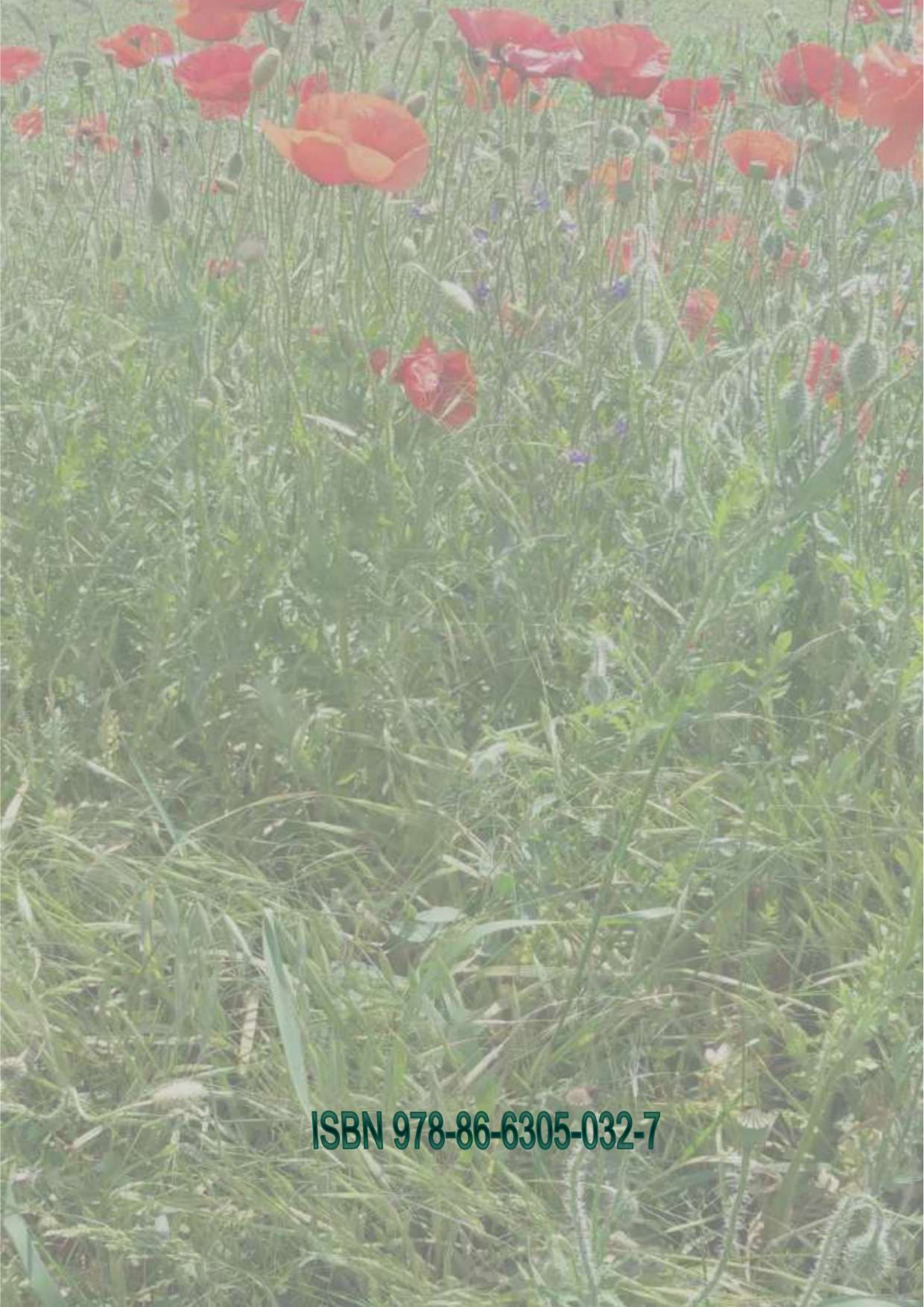


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