

STABILIZATION OF SLUDGE FROM ELECTROPLATING OF PLASTIC MATERIALS FOR SAFE DISPOSAL AND UTILIZATION

A. Simeonova, A. Petkov, J. Balgaranova

*University of Chemical Technology and Metallurgy
8 Kl. Ohridski, 1756 Sofia, Bulgaria
E-mail: petkov@uctm.edu*

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ABSTRACT

In recent times metallized non-conductive materials and in particular metallized plastic materials have come increasingly into use.

The metallization of plastic materials is carried out by physical, mechanical or chemical methods. In practice the most widely applied method is the chemical galvanic one. It is based on the electrical precipitation of a chemical copper or nickel layer on to the plastic surface, which then is a base for the electrochemical precipitation of a three-layered Cu-Ni-Cr overlay. This process causes serious environmental problems because of the generation of sludge and slag of various compositions, although the quantities (several tons up to several dozen tons) are relatively small. Most often such wastes are characterized by their high content of heavy metals.

Because of the absence of a centralized system for collecting and stabilizing of such wastes to ensure their safe disposal or eventual utilization, there is a real risk of environmental pollution because of the leaching and migration of the dangerous waste components.

In the recent investigation sludge from wastewater treatment plant after a process line for the metallization of plastic parts is used. The possibility for fixing the heavy metals contained in it is examined. A three stage method is used: Granulation of the dried and ground sludge with a solution of sodium water-glass; Covering of the granules with a cement layer; Inserting the granules into a concrete matrix as a "light filler". The sludge thus stabilised complies with the prescribed EU standards for disposal and utilization of such wastes.

Keywords: stabilization of heavy metals, metallization.

INTRODUCTION

Metal coating deposition on plastics aims at: improvement of the product appearance, limitation of aging (destruction) and increase of corrosion resistance, adding various specific properties – electric conductivity, magnetic and optical properties, increase of hardness, heat and wear resistances.

As a result of these processes, serious ecological problems arise, ensuing from the generation of although low in quantity (ranging from several tons to several tens of tons annually) sludge and slag of various compositions. In case there is no centralized system to col-

lect such wastes with the purpose of stabilization, which ensures their safe disposal or eventual utilization, there is a real risk of contaminating the environment due to leaching and migration of waste hazardous components. Most often, such wastes are characterized by high content of heavy metals.

In compliance with Directive EC 1999/31 of the Council of the European Union of 26 April 1999 even in the specialized depots for hazardous wastes only stabilized wastes should be received, i.e. subjected to pre-treatment, the aim being to fix the hazardous components in the waste and reduce to minimum the possibility for their leaching and migration because of rain or ground waters.

In the last two decades in the ecological practice, more and more attention is paid to the methods of stabilization of hazardous wastes by investigating different individual and combined technologies. One of the most extensively practiced methods for stabilization of hazardous wastes is the inclusion of the hazardous wastes in a concrete matrix thus decreasing many times the possibility of leaching the hazardous components from them.

The present paper investigates the possibility to fix the heavy metals contained in the sludge from wastewater treatment plant after electroplating of plastic parts.

A stabilization method is suggested based on three stage treatment of the sludge and comprising the following steps: 1) granulation of the dried and milled sludge by solution of soluble soda glass; 2) covering the granules by cement layer; 3) inclusion of the granules in concrete matrix in their capacity of "light filler" for providing the necessary European regulations for disposal of hazardous wastes.

The basic physico-chemical characteristics of the produced concrete samples are also examined with the purpose to assess the possibility to utilize the prepared in that manner concrete mixture for manufacture of light non-critical concrete products.

EXPERIMENTAL

Raw materials used were:

- Sludge from the treatment plant after electroplating of plastic parts. The sludge was quantitatively characterized by ICP AES analysis after acid leaching and conventional chemical methods. Table 1 presents the results.

- Soda glass: soluble soda glass of module $m = 2,4$ and density $r = 1,45 \text{ g/cm}^3$ was used.

- Cement: for surface treatment of the granulated sludge and for the preparation of concrete mixtures Portland cement grade CEM (B – M) 32,5 R was used under BDS EN 197 – 1.

Table 1. Content of hazardous components in the sludge from treatment plant after electroplating of plastic parts.

Hazardous components	Pb	Cu	Ni	Zn	Cr
Content, mg kg^{-1}	140	96520	41300	1450	129510

Method. The granulation of the preliminary dried and milled sludge is performed in disk granulator by using aqueous solution of soluble soda glass as binding reagent. The ratio between the water and soluble glass is 1:1. The granulated sludge of maximum granule size 15 mm is spread in a thin layer and dried in air for 24 h. The dried granules are sifted through a sieve of 4 mm size of the holes, providing in this way granulometric composition of 4 to about 15 mm, which is suitable for a filler of concrete mixtures.

Previous investigations show that granules produced on the base of waste products and binding reagent (soluble soda glass of module $m = 2,4$ and density $r = 1,45 \text{ g/cm}^3$) with satisfactory and very good strength characteristics, after determination of water absorbing, are decomposed in the water. Therefore the second stage of the stabilization of the studied sludge is the surface treatment of the granules. It consists in granules wetting by laitance (50 g of cement and 100 cm^3 water).

The surface treatment of the granules is carried out to decrease the water absorbing and to improve the mechanical strength of the granules as well as to improve their adhesion properties as "light filler" towards the concrete matrix.

The final stage of stabilization is the incorporation of the granules thus treated in the concrete matrix. Standard concrete mixtures are prepared and concrete samples with dimensions 40/40/160 mm are formed.

The so called "percolation test" for assessing the degree of the hazardous components (heavy metals) extracting from the stabilized sludge is used. The prepared concrete samples are also subjected to percolation leaching.

The first 100 ml of the eluate are collected and analyzed by Atomic Absorption Spectroscopy for determination of the metal content (Pb, Cu, Ni, Zn, Cr). The pH of the eluates is also determined.

Table 2 shows the data for the degree of extraction (solubility) of the hazardous components from the stabilized sludge and concrete samples in the eluates of the percolation test as well as the boundary (maximum permissible) values for extractability of hazardous components from stabilized sludge with the purpose to dispose in depots for hazard-

Table 2. Content of the hazardous components in the eluates from the percolation test for the extraction of the stabilized (granulated) sludge and the concrete samples, respectively.

	Pb		Cu		Ni		Zn		Cr		pH
	Norm	Eluate content	Norm	Eluate content	Norm	Eluate content	Norm	Eluate content	Norm	Eluate content	
	mg/dm ³	mg/dm ³	mg/dm ³	mg/dm ³	mg/dm ³	mg/dm ³	mg/dm ³	mg/dm ³	mg/dm ³	mg/dm ³	
Eluate of granulated sludge	15	< 0,3	60	0,95	12	< 0,10	60	< 0,05	15	3,94	10,32
Eluate of concrete samples	15	< 0,3	60	0,52	12	< 0,10	60	< 0,05	15	2,10	11,12

Table 3. Main physico-chemical characteristics of concrete samples produced by incorporation of granulated sludge as “light filler” in a standard concrete mixture.

Characteristics	Test value	Designed grade of light concrete
1. Volume weight of concrete, kg/m ³		
- in dry condition	1758	Light concrete: 500 – 1800
- in wet condition	1914	Lighter concrete: 1800 - 2200
2. Water absorption, %	14,58	-
3. Mechanical strength to pressure, MPa		
- after 7 days	4,0	
- after 14 days	8,25	
- after 28 days	10,62	B 2,5 to B 7,5

ous wastes, in compliance with Directive EC 1999/31 of the Council of the European Union.

Table 3 presents the results of the investigation of the basic physico-chemical characteristics of the concrete samples produced by incorporation of granulated sludge as “light filler” in a standard concrete mixture.

CONCLUSIONS

The applied in the present work three stage treatment of sludge with high content of heavy metals aiming dangerous compound immobilization, differs from the published in the literature methods for stabilization of similar wastes.

The three stage treatment comprises sludge granulation by solution of soluble soda glass followed by surface treatment of the granules with cement milk and their inclusion as “light filler” in standard concrete mixtures. The results from dangerous components leaching test of stabilized sludge and concrete samples show a very good resistance to heavy metal extraction. Lower than the standard required concentrations of dangerous components in the eluate for disposal of dangerous wastes is achieved.

The study is not completely finished There are some aspects to investigate prior the final conclusion to be made. The most interesting is to explain how the metal ions are fixed (immobilized) in the con-

crete matrix and exactly how they are dissolved during leaching. This information will be obtained in the future using SEM (scanning electron microscope) and XRD (X-ray diffraction analysis).

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