Safety Treatment of Hazardous Liquid Waste Using Functionalized Copolymers Prepared by Using Ionizing Radiation

A Thesis

Submitted to Chemistry Department, Faculty of Science, Ain Shams University for the Degree of Ph.D. of science in chemistry

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Approval Sheet

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This Thesis towards a Ph.D. Degree in Chemistry

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List of Abbreviations

Abb.	Full term

AFM .....*Atomic Force Microscopy*
As .....*Arsenic*
ATRP .....*Atom Transfer Radical Polymerization*
AUL .....*Absorbency under Load*
CCP .....*Commercial Chemical Product*
Cd .....*Cadmium*
CMC .....*Carboxymethyl Cellulose Magnetic*
Co.....*Cobalt*
Cr .....*Chromium*
DTA .....*Differential Thermal Analysis*
EW .....*Exempt Waste*
GSG .....*General Safety Guide*
Hg .....*Mercury*
HLW .....*High Level Waste*
IAEA .....*International Atomic Energy Agency*
ILW .....*Intermediate Level Waste*
LLW .....*Low Level Waste*
MB .....*Methylene Blue*
NEA .....*Nuclear Energy Association*
Ni .....*Nickel*
NORM .....*Naturally Occurring Radioactive Materials*
PAAc .....*Polyacrylic Acid*
PAAm .....*Polyacrylamide*
Pb .....*Lead*
P-NP .....*P- Nitro-Phenol*
PSty .....*Polystyrene*
PVA .....*Polyvinyl Alchol*
PVDF .....*Poly Vinylidene Fluoride*
RHA .....*Rice Husk Ash*

List of Abbreviations (Cont...)

Abb.	Full term

SEM .....*Scanning Electron Microscopy*
SSG.....*Specific Safety Guide*
TCLP .....*Toxicity Characteristic Leaching Procedure*
TECDOC.....*Technical Documents*
TGA .....*Thermogravimetric Analysis*
Tl .....*Thallium*
VLLW .....*Very Low Level Waste*
VSLW .....*Very Short Lived Waste*

ABSTRACT

Removal of heavy metals from liquid waste effluents is an important environmental concern in treatment process of hazardous wastes.

During the last decades, considerable effort have been directed towards the development and improvement of materials to be used for removal or decontamination of hazardous waste such as ion exchange materials, ion exchange membranes, ceramic materials, …etc.

This work handles the treatment of hazardous wastes using functionalized hydrophilic hydrogels by the polymerization of acrylic acid, acrylamide, vinyl alcohol individually and in a binary mixture using gamma irradiation as initiator. Further chemical modification to the functional groups of the prepared copolymers carried out to meet the requirements for their applications in waste treatment.

The preparation conditions of the hydrogel composite copolymers such as monomer or binary monomer concentration, radiation dose, solvent and inhibitor concentration and reagents used for the preparation process, was investigated.

The FTIR spectroscopy, Thermal gravimetric analysis (TGA), Differential thermal Analysis (DTA) and swelling behavior studies have been applied for the characterization of the prepared hydrogels. It was found that the maximum metal ions uptake by hydrogels is ordered in sequence as (Cr^{3+}> Co^{2+}> Ni^{2+}) and it depends on the type of hydrogels is ordered in sequence of P(AAm/VA) > P(AAm/AAc) > P(Sty./AAc) polymeric hydrogels.

The metal uptake for all metal ions and copolymers kinds achieved maximum value at around pH=5 after this point adsorption begins to decrease.

The prepared hydrogels are considered as additional materials to be used for safety treatment of hazardous liquid waste.

The chemical behavior of Co^{2+}, Ni^{2+} and Cr^{3+} is similar to Co^{60}, Ni^{58} and Cr^{52}. In this study it is considered that under the same conditions, the removal of Co^{60}, Ni^{58} and Cr^{52} from liquid radioactive waste will be similar to cobalt, nickel and chromium ions.

Key words: Acrylic acid, Styrene, Acrylamide, Vinyl alchol, Hazardous waste, Absorption, Cr, Co, Ni, Radioactive waste, Hydrogels, copolymers.

1. INTRODUCTION

1.1. Definition of Hazardous Waste:

Hazardous waste is a waste with properties that make it potentially dangerous or harmful to human health or the environment. The universe of hazardous wastes is large and diverse. Hazardous wastes can be liquids, solids, or contained gases. They can be the by-products of manufacturing processes, discarded used materials, or discarded unused commercial products, such as cleaning fluids (solvents) or pesticides **(Daniel et al., 2016).**

The Resource Conservation and Recovery Act (RCRA) govern the management of hazardous wastes. There is not a single comprehensive list of hazardous waste that is continuously updated, as hazardous waste identification is a process that involves many steps. To be considered a hazardous waste, a material first must be classified as a solid waste.EPA defines solid waste as garbage, refuse, sludge, or other discarded material (including solids, semisolids, liquids, and contained gaseous materials). If a waste is considered solid waste, it must then be determined if it is hazardous waste. Wastes are defined as hazardous by EPA if they are specifically named on one of four lists of hazardous wastes (F, K, P, U) Wastes are listed as hazardous because they are known to be harmful to human health and the environment when not managed properly, regardless of their concentrations. EPA has

studied and listed as hazardous hundreds of specific industrial wastestreams. These wastes are described or listed on four different lists:

The F list: The F list designates as hazardous particular wastes from certain common industrial or manufacturing processes. Because the processes producing these wastes can occur in different sectors of industry, the F-listed wastes are known as wastes from non-specific sources.

The K list: The K list designates as hazardous particular wastestreams from certain specific industries. K-listed wastes are known as wastes from specific sources.

The P list and the U list (Discarded Commercial Chemical Products): These two lists are similar in that both list pure or commercial grade formulations of certain specific unused chemicals as hazardous provided that the material is an unused commercial chemical product (CCP). A CCP is a substance that consists of the commercially pure grade of the chemical, any technical grades of the chemical, and all formulations in which the chemical is the sole active ingredient.

Characteristic Wastes

Even if the wastes team does not meet any of the four listings explained above, it may still be considered a hazardous waste if it exhibits a characteristic of the following four hazardous traits: