

MITIGATION OF SOLID WASTE AND REUSE OF EFFLUENT FROM PAINT AND VARNISH AUTOMOTIVE AND INDUSTRIAL TREATED BY IRRADIATION AT ELECTRON BEAM ACCELERATOR

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ABSTRACT

One of the most representative industrial segments is the polymeric coatings for house paint, automotive, industrial, marine, maintenance, and repainting markets. The general consumption of paint market in 2010 was 438,364 10³ gallons of paint, in Brazil. However, when produce paints and varnishes, various kinds of solid wastes and liquid effluent are generated. The present research focus on the effluent from resins, water base paint and paint for electrophoresis, automotive industry, and general industrial coatings. The goal of this study is to use ionizing radiation to destroy the pollutants allowing the use of part of effluent as reuse water, and the rest discarded within the specified requirements. Actual industrial effluent samples were irradiated at Electron beam Accelerator applying absorbed doses of 10 kGy, 30 kGy and 50 kGy. The results, in this preliminary stage, showed a reduction of organic compounds and suspended solids.

Keywords industrial effluent, Ionizing radiation, automotive paint

1.INTRODUCTION

The paint industry, only in the western world, represent around 22 billion dollars and according to ABRAFATI (2011) the industry's growth in 2011 will be around 6.7%, which is lower than 2010 that was 10.3%. [1]

Paint can be conceptualized as a film or a layer of polymer, to protect, to signal and to illuminate or even to embellish the substrate on which it is applied. Basically, this polymeric compound is formed by elements such as: resin, pigments, fillers, solvents and additives [1,11,16].

The main component of the paint is the resin, which is responsible by the film formation and also by the protection of the substrate. The pigments are usually formed by inorganic and organic substances which function is to provide color, opacity, and protection. The pigments

of organic origin present more vivid colors, than that of inorganic origin. Solvents are substances used for applying and spreading the paint, for dissolving the resin and for controlling the drying paint among other functions [11].

Finally, agents are additives used in small quantities, to correct a problem or even to give some property. Examples of additives are the antioxidant agents, antibubbles, spreading, thickeners, thyrotrophic, among others [11,16].

Waste and effluent are originated from the paint production process and are referred to later disposal. The effluent that is object of this study come from the equipment washing (pots, buckets, drums, cowls disperser, shovels, trowels, drums, buckets and other tools), and are forwarded to a Industrial Wastewater Treatment Plant, WTPI [11,12].

The effluent treatment objective is the partial or total removal of the pollutants, and involves physical, chemical, and biological methods [5,6,7,13,15]

It is important to point out the characterization and the legal requirements before opting for the technology of industrial effluent treatment, and to remember that the process should seek to address environmental sustainability. The reuse of the treated effluent is one of the possibilities that should be considered in order to minimize the environmental impacts and to reduce the use of natural resources [15].

The processes that involving chemical reactions become more effective in treatment of hazardous waste, however, some of them can cause environmental impacts. These treatments include neutralization, the reduction of color and turbidity. Other reagents that are added at this stage are the flocculants (aluminum, ferric chloride, polymers) that induce sedimentation of the pollutants. However, for various industrial processes (especially organic) these methods are insufficient for complete removal of impurities, especially with regard to Biochemical Oxygen Demand, BOD, and color [2,3,5,6,7,12,13,17].

New technologies for the treatment of aqueous effluents in Brazil are gradually becoming available and more competitive. Although the tendency is be part of the market alongside traditional methods. These techniques include, for example, the modern separation techniques, ion exchange, electrodialysis, ultrafiltration, reverse osmosis and Advanced Oxidation Prozesse, AOP [9,10,14,15].

Chemical oxidation processes are promising to restore the environment. These processes aim the degradation of toxic organic compounds, and formation of simpler molecules. The most efficient path for the oxidation is the attack by hydroxyl radical (OH). The Advanced Oxidation Process (AOP) using electron accelerators have been adopted by several countries for the removal of organic compounds and biological degradation in domestic sewage. The electron beam irradiation has shown to be efficient in the degradation of organic compounds such as benzene, toluene, xylene and phenol, and also chlorinated compounds (ethylene dichloride, chloroform) and oxygenates such as methylisobutylketone. [8,9,10,14,].

Irradiation leads to the breakdown of compounds into simpler molecules and radicals and the latter can recombine to form other molecules. Several by-products of reactions have been

identified in irradiated solutions. Getoff study of degradation of chloroform, found mainly aldehyde as a stage of degradation [9,10]

The object of this study is the industrial effluent from the process of resins, water based paint and electrophoresis paint. This effluent is composed of waste generated during the cleaning of water-based paint, paint's tanks and washing paint pots electrophoresis; washwater tanks manufacture and storage of resin materials, water washes of the resin reactors and washwater of filling machines for water-based paints.

2. EXPERIMENTAL

2.1. Sampling

The sampling was performed in accordance with technical standard (ABNT NBR 5764, 1986). All samples were collected at the entrance of the Industrial Wastewater Treatment Plant. The frequency of collection is monthly, in order to determine the variations of the same due to seasonality of the production process of paints and waste generation and waste paint. For the present study it was considered the samples collected in two consecutive months, and are called 1 and 2.

2.2. Radiation Processing

The electron beam irradiation was carried out using the Radiation Dynamics Inc. USA Electron Beam Accelerator, with 1.5 MeV and 37 kW, in batch systems. The irradiation parameters used was 4.0 mm sample width, 112 cm (94.1%) scan and 6.72 m/min speed conveyor stream. The Applied absorbed doses were 10 kGy, 30 kGy and 50 kGy. In Figure 1 the samples prepared for electron beam irradiation are showed.



Figure 1. Samples prepared for electron beam irradiation

3. RESULTS AND DISCUSSION

In Table 1 are presented the physical-chemical characterization of the samples and chemical analysis compared to Specification in the Article 19A, before irradiation. All the parameters of both samples have lower values than the specified in the Article 19A.

Table 1. Chemical Analysis of samples compared to Specification – Article 19A

Parameter	Specification Article 19 A Dec. 8468/76	Sampling 1	Sampling 2	Unit
Total Arsenic	1500	<10.0	<10.0	µgAs/L
Total Cadmium	1.5	<0.05	<0.05	mgCd/L
Total Lead	1.5	<0.50	<0.50	mgPb/L
Total Cyanide	0.2	<0.05	<0.05	mgCN/L
Total Cooper	1.5	<0.10	<0.10	mgCu/L
Hexavalent Chrome	1.5	0.65	<0.01	mgCr ₆ /L
Total Chrome	5.0	0.91	0.07	mgCr/L
Total Tin	4000	1258	<25.00	µgSn/L
Total Phenol	5.0	<0.10	<0.10	mg/L
Soluble Iron	15.0	<0.30	<0.30	mgFe/L
Fluoride	10.0	1.39	0.86	mgF/L
Total Mercury	1500	<0.50	<0.50	µgHg/L
Total Nickel	2.0	<0.05	<0.05	mgNi/L
Oil and Total grease	150	11.9	11.5	mg/L
pH/temperature	6.0 -10	9.47 / 19	6.91 / 21	pH/°C
Total Silver	1.5	<0.02	<0.02	mgAg/L
Total Selenium	1500	<10.00	<10.00	µgSe/L
Sedimentable Solids	20	0.1	0.1	mg/L
Total Sulfate and Sulfide	1000	88.95	94.86	mgSO ₄ /L
Total Sulfide	1.0	<0.10	<0.10	mgS/L
Total Zinc	5.0	0.20	0.22	mgZn/L

After irradiation the samples presented different aspects, depending on the received dose. In Figure 2 can be observed that the sample 1 became clearer after irradiation.



Figure 2 Irradiated samples

In Table 2 the results of oil and grease, pH, and sedimented solids of sample 1 and 2 after irradiation are presented. Regarding to oil and grease content, it was observed an increasing of 549% for sample 1 irradiated with 10 kGy, 223% for the dose of 30 kGy and 50 kGy to 353%. The second sample presented an increasing of 295% to 10 kGy, 205% for the dose of 30 kGy, and a decreasing of 99.13% in sample irradiated with 50 kGy. These results are not expected, but it will be investigate elsewhere. The pH presented a decreasing in the case of sample 1, from 9.47 to 6.91 and an increasing in sample 2, which was neutral before irradiation.

Table 2. Physical chemical analysis after electron beam irradiation

Sampling	Untreated	10 kGy	30 kGy	50 kGy
Sampling 1				
Oils and Grazes	11.9	77.3	38.5	53.9
pH/temperature	9.47 / 19	9.47 / 19	7.94 / 19	6.91 / 21
Sedimented solids	0.1	17.0	8.0	8.0
Sampling 2				
Oils and Grazes	11.5	45.4	35.9	<0.10
pH/temperature	6.91 / 21	7.61/ 21	9.10 / 21	6.94 / 21
Sedimented solids	0.1	11.0	0.3	0.1

Regarding the content of TOC (Total Organic Carbon) of the blank sample (effluent collected at the station entrance and without irradiation treatment) shown in Table 3, it was noted an decreasing in the values obtained. This fact is due to the breakdown of organic molecules existing in the effluent by irradiation.

Table 3. Variation of the TOC content in samples of effluent from paint irradiated with 10, 30 and 50 kGy

Sampling	Untreated (mg/L)	10 kGy (mg/L)	30 kGy (mg/L)	50 kGy (mg/L)
1	5935	5773	6047	5640
2	8526	8040	7894	7890

In the study of AOP (Advanced Oxidation Process) with ionizing radiation it is important to point out that not only the removal of pollutants is important, but should be considered the formation of byproducts after irradiation. To determine the products that can be formed, it is necessary to study the destruction mechanism of the compound.

In Figure 3 is showed the obtained chromatogram of untreated sample. The mains compounds identified by mass spectrometry was MIK (Methyl Isobutyl Ketone), tetrachloroethylene,

xylene and a mixture of alcohol that was not totally identified yet. These compounds were analyzed in irradiated samples and its removal were calculated and presented in Table 4. The compounds MIK, tetrachloride and xylene were removed with higher efficiency than the alcohol mixture, that is the main contaminant in these effluent and have to be investigated.

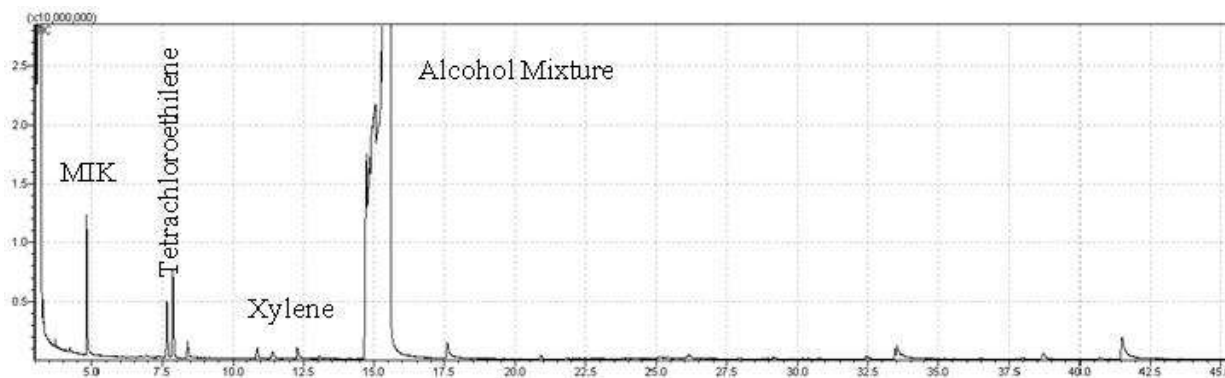


Figure 3 Chromatogram of sample 1 with the identification of the main compounds

Table 4. Removal (%) of main organic compounds after electron beam irradiation of two sampling in different absorbed dose

Sampling	Absorbed Dose		
	10 kGy	30 kGy	50 kGy
Methylisobuthylketon			
1	100.00	100.00	100.00
2	40.79	40.79	40.79
Ethybenzene			
1	68,51	72,56	81,69
2	53,84	88,62	92,41
Tetrachloroethylene			
1	66,93	23,59	60,21
2	81,77	51,57	50,50
Xileno			
1	74,32	99,67	31,70
2	0	32,06	35,30
Alcohol Mixture			
1	19,83	34,35	21,02
2	00	28,68	31,43

4.CONCLUSION

These preliminary results showed promissory effects of electron beam irradiation on effluents from paint industry, studies are necessary for evaluation of the best application of this technology.

This study is relevant because it is an alternative treatment that can minimize the environmental impacts of these industrial effluents.

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