



Treatment of Some Radioactive Wastes By  
Using New Chelating Membranes

El-Sayed A.Hegazy, H.Kamal, K.El-Adham<sup>\*</sup>, El-Sayed A.Soliman<sup>\*\*</sup>,  
M.Abdel Geleel<sup>†</sup>

*National Centre for Radiation Research and Technology  
P.O.Box 29, Nasr City, Cairo, Egypt  
\*National Centre for Nuclear Safety and Radiation Control  
\*\*Ain-Shams University, Faculty of Science*

### ABSTRACT

The preparation of chelating membranes containing nitrile and carboxylic acid as functional groups was investigated. The modification of such membranes by chemical treatments to produce significant changes in their properties was studied. This modification results in a higher rate of exchange and higher capacity. The applicability of such modified membranes in the removal of Co-60 and Cs-137 from their wastes were tested. The dependence of these radioactive nuclides uptake on the time and degree of grafting for HCl-, NH<sub>2</sub>OH- and KOH-treated membranes was investigated. It was found that the adsorption rate and capacity were higher for KOH-treated membrane than those for the NH<sub>2</sub>OH and HCl treated ones. The prepared grafted membranes have a good affinity towards the adsorption or chelation with Co-60 and Cs-137. This result may make such prepared materials acceptable for practicable use in some radioactive waste treatments and recovery.

*Key words: Radiation, Grafting, Membranes, Radioactive Waste Treatment.*

### INTRODUCTION

Low level liquid radioactive waste is generated by nuclear power reactors, nuclear fuel cycle, hospitals, universities, radioisotope manufactures, research institutes and other organizations using radioactive materials<sup>(1)</sup>. At present, the most effective method for the treatment of liquid radioactive waste is removing the activity by passing the solution through an ion exchange resin<sup>(2)</sup>. Radiation graft copolymerization of different monomers onto low density polyethylene for removal of metal ions such as Fe, Cu, Pb,...etc. which are commonly exist in waste water was studied<sup>(3,4,5)</sup>.

The present study aims to synthesize graft copolymers by radiation grafting of AAc/AN binary monomers system onto low density polyethylene (LDPE), high density polyethylene (HDPE) and polypropylene (PP) for the treatment of Co-60 and Cs-137 wastes. Characterization and the possibility of their practical use in such application were investigated.

### EXPERIMENTAL

#### *Materials*

Low density polyethylene (LDPE), high density polyethylene (HDPE) and polypropylene (PP) films of thickness: 70, 30 and 55  $\mu\text{m}$ , respectively, were produced by EL-Nasr Co. for Medical supplies, Egypt. Acrylic acid (AAc) of purity 99% (Merck) and reagent grade acrylonitrile (AN) of purity 99.3 %

(Merck) were used as received. Other chemicals, such as solvents, inorganic salts, acids and other reagents were reagent grade.

### *Graft Copolymerization*

The direct radiation grafting method was used as a technique. The irradiation was carried out using Co-60 gamma rays at a dose rate 0.6 Gy/s in nitrogen atmosphere. After irradiation the grafted films were removed and soaked in DMF then washed by hot distilled water to extract the embedded homopolymer. These films were then dried at 40 - 50 °C in oven for 24 h. to constant weight. The degree of grafting was calculated by percentage increase in weight as follows:

$$\text{Degree of Grafting (\%)} = [(W_g - W_o) / W_o] \times 100$$

Where  $W_o$  and  $W_g$  are the weights of blank and grafted films, respectively.

### **Chemical Treatment of The Graft Copolymers:**

Improvement the hydrophilic and ion-exchange properties of the graft copolymers was carried out by treating them with aqueous KOH (3%), 1:1 alcoholic solution containing 3% hydroxylamine - HCl at pH 7 or with HCl (3mole %) using a reflux system at 90 °C for 16 h. The treated films were then immersed in bi-distilled water for 24h to remove the excess reagents and then dried in oven at 40-50 °C for 24h.

### *Water Uptake Measurement*

The clean, dried grafted films of known weights were immersed in distilled water at 25°C until equilibrium was reached (almost 24h ). The films were then removed, blotted quickly with absorbent paper and weighed. The percent of water uptake was calculated as follows:

$$\text{Water Uptake (\%)} = [(W_s - W_g) / W_g] \times 100$$

Where  $W_g$  and  $W_s$  represent the weights of dry and wet grafted films, respectively.

### *Differential Scanning Calorimetry (DSC)*

Melting temperature ( $T_m$ ) and heat of melting ( $H_m$ ) were determined using Perkin - Elmer DSC-7 at a heating rate of 10 °C/min under nitrogen atmosphere.

### *Thermal Gravimetric Analysis (TGA)*

(TGA) curves were performed using Perkin Elmer 7-TGA at a heating rate of 20 °C/min. under nitrogen atmosphere.

### *Radioactive Waste Treatment*

Radioactive liquid wastes were measured by using Multichannel Analyzer Model 800 A. Co-60 and Cs-137 wastes were obtained from the Decontamination Unit, Radiation Protection Department , Nuclear Research Centre, Atomic Energy Authority. The grafted treated membrane was immersed in the liquid waste and the remaining activity was then measured after removing the film.

$$\text{Radioactive Isotope Uptake (\%)} = \{ (I_o - I) / I_o \} \times 100$$

where  $I_0$  and  $I$  represent the initial and remaining activities, respectively.

## RESULTS AND DISCUSSIONS

### *Effect of Comonomer Composition*

Figure (1) shows the effect of comonomer composition on the grafting of AAc/AN-mixture onto LDPE, HDPE and PP films in presence of H<sub>2</sub>O/DMF (30/70 wt.%) as a diluent mixture. It is clear that, the grafting yield decreases with increasing AAc content in the mixture until it reaches its lower value at 100 % AAc. It seems that the presence of AN enhances the grafting of AAc, as it was found in other binary graft copolymerization systems<sup>(6)</sup>. The increase in grafting yield with AN concentration in the feed solution may be due to its higher polarity strength compared with AAc monomer<sup>(7)</sup>.

Solvent type may also have a strong influence on the total grafting yield. DMF is a good solvent for the hydrophobic AN monomer, consequently, as the content of the hydrophilic AAc monomer increases, the diffusion of the comonomer into the active sites decreases at this lower content of water in the solvent mixture.

### *Effect of Monomer and Comonomer Concentration*

The effect of aqueous AAc concentration and AAc/AN comonomer (10/90 wt %) in H<sub>2</sub>O/DMF (30/70 wt %) on the grafting yield onto LDPE, HDPE, PP films are investigated and shown in Figures (2,3) respectively. For the grafting of aqueous AAc, it is obvious that the grafting yield initially increases with AAc concentration, thereafter, it tends to level off at higher monomer concentration. This is due to the formation of highly viscous homopolymer and consequently the diffusion of AAc to the bulk polymer becomes somewhat difficult. Whenever, in the grafting of AAc/AN binary systems, it can be seen that, the grafting yield increases with comonomer concentration and an acceleration for the grafting process was occurred at comonomer concentration 30 wt %. It is also observed that at a given monomer concentration, the grafting yield is higher for AAc/AN binary mixture than that for the individual grafting of AAc.

The increase in the grafting yield with monomer concentration may be due to the increase in diffusion rate of the monomer into the bulk polymer. The acceleration occurred at AAc/AN comonomer concentration 30 wt % may be due to the so called "gel effect" which enhances the propagation process and retards the termination of radicals because of the low mobility of the growing chain radicals. The chain transfer from the growing grafted chain to the backbone polymer, thus starting a new graft chain, may be also have an effect.

### *Effect of Irradiation Dose*

The effect of irradiation dose on the degree of grafting of (AAc/AN) comonomer is investigated and shown in Fig. (4). For PP and HDPE polymer substrates, the grafting process goes through an "induction period" which is a typical behavior of grafting onto crystalline polymers<sup>(8)</sup>. Thereafter, the degree of grafting increases with irradiation dose. As well known that the free radicals formation increases with irradiation dose to reach a maximum value at a certain dose and no longer increase with increasing dose due to recombination of the free radicals at high doses, accordingly, the degree of grafting tends to level off. It is also found that no induction period was observed for LDPE polymer substrate. This is due to the difference in diffusion coefficient as compared with those of PP and HDPE. It can be noticed that, the grafting of AAc/AN comonomer onto LDPE films proceeds successfully with higher degrees of grafting than those of onto PP and HDPE films, at a given reaction condition. It can be suggested that the diffusion of the comonomer solution into amorphous LDPE matrices is much

easier than into semicrystalline PP and HDPE films and the polymer morphology plays a great role in the grafting process.

### *Water Uptake Properties*

The swelling of the prepared membranes in water was studied for LDPE film having different degrees of grafting and the results are shown in Figs.(5). It can be seen that the water uptake increases with increasing graft yield due to the increase in hydrophilicity of such graft copolymers. The chemically treated grafted membranes possess much higher water uptake than the untreated ones. The treatment of nitrile group with HCl convert it to the amide group and the alkaline treatment of PAN with KOH and  $\text{NH}_2\text{OH}$  convert the nitrile to carboxylate and amidoxime groups, respectively.<sup>(9,10)</sup> It must be noted that, the swelling character for KOH-treated graft copolymers is higher than those treated with  $\text{NH}_2\text{OH}$ , due to the influence of carboxylate unit on the properties of the polymer. The above results demonstrated that, the KOH hydrolyzed membranes have a stronger affinity to water than the  $\text{NH}_2\text{OH}$  and HCl-treated ones.

With increasing degree of grafting the contribution of the decrease in crystallinity of the membrane in regulating the water penetration is in addition to the increase in hydrophilicity of the amorphous region<sup>(11)</sup>. The above results indicated that, the swelling behavior depends mainly on the amount and form of functional reactive groups introduced into the polymer substrate by grafting.

### *Thermal Analysis*

DSC and TGA were used to investigate the thermal stability and the changes in thermal properties of LDPE-g-P(AAc/AN) films and the treated ones with KOH,  $\text{NH}_2\text{OH}$  and HCl.

#### *Differential Scanning Calorimetry (DSC)*

DSC analysis has been carried out for the base polymer, graft copolymer and grafted treated membranes and the results are given in Fig.(7). It can be seen that, the grafted membranes show an endothermic peak with  $\Delta H_m$  values depending on the degree of grafting and the form of introduced functional groups by different chemical treatments of the graft copolymer.

Table (1) shows the thermochemical features as calculated from the crystalline melting transitions behavior of the first DSC scans. It can be seen that, for the untreated grafted membranes, the melting temperature ( $T_m$ ) and heat of melting ( $\Delta H_m$ ) of the graft copolymer is reduced as compared to the blank polymer.

Table (1)

The effect of grafting and chemical treatment on  $T_m$  and  $\Delta H_m$  for LDPE-g- P(AAc/AN).

Treatment Media	% G raft	$T_m$ ( $^{\circ}\text{C}$ )	$\Delta H_m$ (j/g)
blank	----	105.5	69.1
untreated	80	104.9	28
untreated	218	100.5	21.2
HCl	226	106.7	7.1
$\text{NH}_2\text{OH}$	224	105.7	50.2
KOH	240	98.2	6.8

The introduction of (218 wt %) of P(AAc/AN) into LDPE causes a depression of 5 °C in the  $T_m$  and a significant drop in  $\Delta H_m$  by 47.9 j/g. However, due to chemical treatment of such graft copolymers with HCl,  $NH_2OH$ , and KOH a slight increase in  $T_m$  for the graft copolymer treated with HCl and  $NH_2OH$  treated membranes while a decrease in  $T_m$  for the KOH treated ones is observed.

The observed decrease in  $T_m$  and  $\Delta H_m$  with grafting indicated that grafting affects the crystalline structure of LDPE.  $\Delta H_m$  decreased as the degree of grafting increased due to the amorphous nature of the incorporated P(AAc/AN) and the crystalline distortion occurred as a result of their grafting onto LDPE films. It is also observed that, for HCl treated membranes there are two distinctive endothermic peak i.e. two transition phases for the treated and untreated moieties. The area under peak ( $\Delta H_m$ ) is a commulative heat of melting for both phases which means that each polymer shows its characteristic melting endotherm in an incompatible mixture.

Table (1) shows also that, the treatment with KOH causes a decrease in  $T_m$  and  $\Delta H_m$  of ~ 2.3 °C and 14.4 j/g while the treatment with  $NH_2OH$  results in increasing  $T_m$  and  $\Delta H_m$  by 5.2 °C and 29 j/g. These results suggest that, the crystalline distortion is more pronounced in the KOH-treated membranes than the  $NH_2OH$ -treated ones due to the higher polarity of the carboxylate groups than the amidoxime ones. Consequently, the form of the incorporated functional groups also affects the crystalline structure of the grafted LDPE.

Figure (7) shows that, on heating the samples up to 330 °C in the same heating run, all the samples showed a well-pronounced exothermic transition in the temperature range (178.5-328.5 °C). LDPE-blank did not show any transition in this temperature range. This exothermic transition in the graft copolymer can be attributed to the anhydride formation reaction as reported in literature<sup>(12)</sup>.

It also observed that, the peak temperature ( $T_b$ ) increases with grafting and the area under the peak shows an increasing trend with increasing degree of grafting. However, the shape of the thermograms remains almost the same, except for HCl hydrolyzed membrane. The calculated heat of reaction ( $\Delta H$ ), and ( $T_p$ ) corresponding to different LDPE graft copolymers are presented in Table (2).

Table (2)

Heat of reaction and peak temperature of LDPE-g-P(AAc/AN) before and after treatment by using DSC scan.

Treatment Media	% Graft	$T_1$ (°C)	$T_2$ (°C)	$T_p$ (°C)	$T_0$ (°C)	$T_p - T_0$	$\Delta H$ (j/g)
Untr.	80	192.8	296.3	264.7	255.6	9.11	-367
Untr.	218	178.5	307	271.4	246.8	24.5	-612
HCl	227	178.5	314.2	278.8	216.4	62.4	-665
$NH_2OH$	224	178.5	328.5	272.3	225.2	47.1	-1073
KOH	240	185.6	296.3	272.6	258.8	13.8	-438
HCl	188	178.5	310.6	280.7	245	35.6	-590
$NH_2OH$	184	192.8	321.3	274	231.3	42.7	-903
KOH	162	216	300	273.6	255.6	18	-354

The analysis of the DSC scan showed that the initial temperature ( $T_1$ ) and onset temperature ( $T_0$ ) decreases with increasing degree of grafting indicating that the dehydration process increases with grafting and initiated at lower temperature. ( $T_p - T_0$ ) is a measure of overall rate of dehydration, the

smaller the difference, the greater the rate of dehydration reaction. An increase in the  $T_p - T_0$  value with grafting suggests a decrease in the overall rate of reaction. This may be due to the formation of transient crosslinking through the H-bonding of the carboxylic acid groups which increases with grafting and retard the dehydration process. It is also observed that the rate of dehydration for the low graft yield treated membranes is of the sequence  $KOH > HCl > NH_2OH$ . However, the rate of dehydration for the high graft yield treated membranes is of the sequence  $KOH > NH_2OH > HCl$ . In addition to the nature of their functional groups, thermal behavior is affected by tacticity and sequence distribution of these groups in the polymer chain.

The higher weight loss in the temperature range 175-300 °C for  $NH_2OH$ -treated membranes confirm that the amidoxime groups participate in the dehydration process which agree with that of DSC studies.

Table (2) shows that the heat of dehydration ( $\Delta H$ ) increased with degree of grafting from 367 J/g for 80 % graft to 612 for 218 % which indicate that the increase in -COOH groups contents in the graft copolymer increases the dehydration process. The increment in  $\Delta H$  for  $NH_2OH$ -treated membranes suggested that, the presence of amidoxime groups enhances the dehydration process.

### *Thermal Gravimetric Analysis (TGA)*

TGA thermograms for the blank, grafted and grafted treated LDPE films are presented in Figs.(8,9). Table (3) reveal that there are three distinct steps of weight loss. The first step of weight loss in the range of 175-300 °C may be attributed to the elimination of side products through the anhydride formation as indicated from DSC scans at this temperature range. The weight loss below 175 °C is attributed to the removal of absorbed water which is absent in the thermogram of LDPE blank. It can be seen that, the absorbed water is much higher for  $KOH$ -treated and  $NH_2OH$ -treated membranes compared to the untreated and  $HCl$  - treated ones due to the higher hydrophilicity of these membranes. The second and third steps observed in the temperature ranges of 300 - 500 °C and 500 - 600 °C, respectively are the regions of major weight loss which is attributed to degradation of graft side chains and the polymer backbone chains.

Table (3)

Weight loss of blank, LDPE-g- P(AAc/AN) and chemically treated membranes having different degrees of grafting at different decomposition temperatures.

Treatment media	Grafting (%)	Weight loss (%)			
		50-175 °C	175-300 °C	300-500 °C	500-600 °C
blank	---	0.0	2.9	90.2	8.5
untreat.	213	1.6	4.4	31.9	19
HCl	200	0.8	2.9	29.9	21
$NH_2OH$	210	10.3	23.4	21.7	21.3
KOH	215	11.3	4.1	44.3	4.9
HCl	166	1.2	3.3	25	29.1
$NH_2OH$	185	9.8	19	29.3	22.1
KOH	167	10.2	13.9	33.2	1.6

## Application of The Prepared Membranes in Radioactive Waste Treatment:

The prepared modified membranes were employed for the removal of Co-60 and Cs-137 which are the most commonly exist in liquid radioactive wastes.

### *Effect of Time*

The time of treatment is very important factor due to radiation safety, economical reason and radiation exposure to the workers. Also, the efficiency of membrane in waste treatment can be determined from the time required to adsorb the maximum capacity of radioisotopes by adsorption or chelation with its functional groups. In this respect, the dependence of radioisotopes uptake on the time for the treated membranes is shown in Tables (4,5).

The results show that the radioisotopes uptake increases as the time increases and it is very fast to its maximum value. The PP-based membrane adsorbs most of the loaded radioisotopes quickly in the initial 30 mins. It can be also observed that, the adsorption rate and maximum capacity obtained were higher for KOH-treated membranes than those of the  $\text{NH}_2\text{OH}$  and HCl-treated ones and the maximum uptake is reached after 1 hr for PP-g-P(AAc/AN), and 2 hr for LDPE-g-P(AAc/AN).

Table (4)

Effect of time on the uptake of Co-60 and Cs-137 using untreated and treated PP-g-P(AAc/AN) having degree of grafting; 98 %.

Time (min.)	Co- Uptake %		Cs-Uptake %	
	Untreated	KOH-Treated	Untreated	KOH-Treated
1	0.05	35.4	0.0005	30.5
2	0.75	59.9	0.001	48.5
3	2.3	77.8	0.003	64.1
4	3	86	0.01	71
5	3.8	88	0.01	77.4
10	4.3	89.1	0.1	79.2
15	4.7	89.9	0.1	79.4
30	4.9	90.1	0.2	79.8
45	5	90.3	0.4	79.9
60	5.2	90.3	0.5	80.1
120	5.2	90.4	0.6	80.2
1440	5.3	90.4	0.6	80.2

Table (5)

Effect of time on the uptake of Co-60 and Cs-137 using untreated and treated LDPE-g-P(AAc/AN) membranes having degree of grafting; 240.

Time (min.)	Co-60 Uptake %				Cs-137 Uptake %			
	Untreated membrane	KOH-treated	NH <sub>2</sub> OH-treated	HCl-treated	Untreated membrane	KOH-treated	NH <sub>2</sub> OH-treated	HCl-treated
10	1.3	11.9	9.8	6.3	0.002	7	6.4	2.2
15	2.1	19.3	14.9	11.5	0.003	11.7	8.5	4.5
30	2.8	26.4	20.1	16.8	0.004	15.7	11.9	5.7
45	3.1	31.8	25.3	21	0.007	17.1	15.7	7.2
60	3.3	35.5	27.1	23.5	0.011	17.7	16.7	7.2
90	3.8	36.7	28.2	25.4	0.065	20.3	18.3	7.4
120	4.2	37.4	28.8	25.9	0.12	20.6	18.7	7.6
180	4.4	37.9	29.6	26.4	0.2	20.8	18.8	7.6

The chemically-treated membranes gave a higher radionuclide uptake due to the high diffusion rate caused by the improved hydrophilicity. The adsorption efficiency of HCl and NH<sub>2</sub>OH treated membranes is less than KOH-treated ones due to the difference in swelling behavior.

#### *Effect of Degree of Grafting*

It is demonstrated that, the degree of grafting plays an important role in determining the isotopes uptake from their liquid wastes. Tables (6,7) show the effect of different percent graft on the uptake of Co-60 and Cs-137 from their liquid radioactive wastes at immersion time 1 hr by using LDPE and HDPE grafted with P(AAc/AN) and treated with KOH or NH<sub>2</sub>OH.

Table (6)

Effect of percent graft on the treatment of Co-60 and Cs-137 liquid wastes by using chemically treated HDPE-g-P(AAc/AN).

Degree of Grafting (%)	Co-60 Uptake (%)		Cs-137 Uptake (%)	
	KOH	NH <sub>2</sub> OH	KOH	NH <sub>2</sub> OH
0.0	1.0	0.4	0.7	0.3
41	17.6	15.1	7.8	6.9
51	18	15.8	10.4	8.3
61.4	19	16.9	11.3	10.6
73.8	20	18.7	12.9	11.9
82.5	22.9	20	14.9	14



Table (7)

Effect of percent graft on the treatment of Co-60 and Cs-137 liquid wastes by using chemically treated LDPE-g-P(AAc/AN).

Degree of Grafting (%)	Co-60 Uptake (%)		Cs-137 Uptake (%)	
	KOH	NH <sub>2</sub> OH	KOH	NH <sub>2</sub> OH
155	37.5	29.9	20.4	17.6
183	27.3	21.2	13.7	13.9
219	29.8	24.0	15.4	16.5
240	35.5	27.1	17.7	16.7
273	29.1	23.7	15.2	15.8

The radionuclide uptake (%) for HDPE membranes increases with degree of grafting. However, for LDPE membrane, it gradually decreases with increasing degree of grafting. Meanwhile, the uptake (%) of Co-60 is higher than Cs-137 for both membranes.

These results suggested that, the efficiency of these membranes is a function of the number of functional groups introduced in the grafted copolymer and their subsequent ability to adsorb or chelate ions. By introducing carboxylate groups via KOH-treatment the adsorption properties are increased as well as chelating ligands derived from these groups. The adsorption ability of the grafted membrane decreased significantly at higher percent graft > 150 for LDPE - base polymer Table (7). This result can be reasonably explained by considering the content of crosslinked network structure that formed at high degrees of grafting. Such crosslinks may restrict the extraction and diffusivity of radioisotope via such network structure. As a consequence, no significant further increase in radioisotope uptake at higher degrees of grafting is found.

#### *Effect of Initial Activity*

Tables 8 (a,b) shows the effect of initial activity on the uptake of Co-60 and Cs-137 from their liquid radioactive wastes by using different prepared membranes with different base polymers.

Table 8 (a,b)

Effect of initial activity on the treatment of Co-60 (a) and Cs-137 (b) liquid wastes by using untreated and treated LDPE-g-P(AAc/AN), degree of grafting; 240 %, emmersion time; 1.5 hr.

Table 8 (a)

Initial Activity (C/min)	Co-60 Uptake			
	Untreated membrane	KOH treated	NH <sub>2</sub> OH treated	HCl treated
35325	7.1	38.4	30.3	17.7
32416	6.4	34.1	25	16.1
30228	5.8	31.3	22	15.6
25285	5.4	28.4	18.8	14.2
20516	4.9	27.1	16	13.7
18326	4.5	26	14	13.1

Table 8 (b)

Initial Activity (C/min.)	Cs-137 Uptake			
	Untreated membrane	KOH treated	NH <sub>2</sub> OH treated	HCl Treated
35325	5.1	22.6	11.9	13.8
32416	4.6	21.1	11.2	12.5
30228	3.7	20	11	11.6
25285	3.5	19.7	10.8	10.9
20516	3.5	19.1	10.6	10.2
18326	3.5	18.7	10.3	9.9

Table 9 (a,b)

Effect of initial activity on the treatment of Co-60 (a) and Cs-137 (b) liquid wastes by using untreated and treated HDPE-g-P(AAc/AN), degree of grafting; 51 %, emmersion time; 1.5 hr.

Table 9 (a)

Initial Activity (C/min.)	Co-60 Uptake			
	Untreated mem	KOH treated	NH <sub>2</sub> OH treated	HCl Treated
35325	6.1	22.3	19.3	11.5
32416	5.7	21	18.8	10.4
30228	5.3	19.4	17.9	9.5
25285	5.0	18.8	16.8	8.6
20516	4.7	17.7	16.1	7.9
18326	4.4	15.8	14.8	7

Table 9 (b)

Initial Activity (C/min.)	Cs-137 Uptake			
	Untreated mem	KOH treat	NH <sub>2</sub> OH tre	HCl Treat
35325	5	13.2	11.9	9.7
32416	4.7	12.6	11.2	8.4
30228	3.5	11.9	11.0	7.5
25285	3.4	11.7	10.8	7.1
20516	3.3	11.5	10.6	6.6
18326	3.4	11.4	10.4	6.1

These tables showed that the amount of isotope adsorbed by each membrane increased with the initial activity but different levels were recorded depending on the type of treatment and the base polymer. The isotope uptake for Co-60 is higher than for Cs-137. These results suggest that the divalent isotopes Co<sup>2+</sup> tend to make stable complex with active groups rather than monovalent ones Cs<sup>+</sup> (13). Also, the higher affinity of the prepared membranes toward Co-60 than Cs-137 waste may be due to the smaller ionic radii of Co.

## Conclusion

It can be concluded that, the KOH-treated grafted PP is the most efficient membrane in reducing the activity of these radioactive liquid wastes to a great extent. Such decrement in activity reaches to ~90 % for Co-60 and 80 % for Cs-137. The KOH treated membranes have strong ability to separate Co-60 and Cs-137 from their liquid radioactive wastes than those of NH<sub>2</sub>OH and HCl-treated ones. Generally, the prepared membranes exhibited an ability to adsorb radioisotope such as Co-60 and Cs-137 and this is particularly true with all grafting levels.

## REFERENCES

- 1-IAEA, TECDOC-661, Review of available options for low level radioactive waste disposal (1992).
- 2- Nuclear Science and Technology, Commission of the European Communities, EURE 13252 EN (1991).
- 3- Hegazy E.A, Abd El-Rehim H.A., Shawky H.A, Radiat. Phys. Chem., 57(1), (2000).
- 4- Hegazy, E.A., Abd El-Rehim H.A., Ali A.M.I., Nowier H.G., Aly H.F.; J. Nuclear Instrument and Methods in Physics Research B 151, 393, (1999).
- 5- Abd El-Rehim H.A., Hegazy, E.A.; E.A.; El-Hag Ali A.; Reactive and Function Polymer, 44(107),(2000).
- 6-Hegazy E.A., Osman M.B., Moustafa, A. and Abdel-Maksoud A.M.; J. Polym. Int.; 36(1), 47 (1995).
- 7-Hegazy E.A., Osman M.B., Mokhtar S.M. and Abo EL-Khair; J. Radiat. Phys.Chem., 36(3), 356 (1990)
- 8-Hegazy E.A.,Taher N.H. and Kamal H.; J. Appl.Polym.Sci., 38, 1229 (1989).
- 9- Jerry March, Advanced Organic Chemistry,3<sup>rd</sup> Edn., Chapter16, P788, Wiley-Interscience Publication, John Wiley and Sons, N.Y.(1985).
- 10- Kabay N., Katakai A., Sugo T. and Egawa H.; J. Appl. Polym. Sci.,49,599 (1993).
- 11- Gupta B.D., Buchi F.N. and Scherer G.G.; J. Polym. Sci. Part A: Polym.Chem., 32, 1931(1994).
- 12- Bajaj P., Meenakshi G and Charan R.B.; J. Appl. Polym. Sci., 51, 423 (1994).
- 13- EL-Sharnouby A. K., Abdel Gawad A. S., Shinawy R.M.K., and Omar H. A.; Arab Journal of Nuclear Science and Applications; 13(1), (1998)

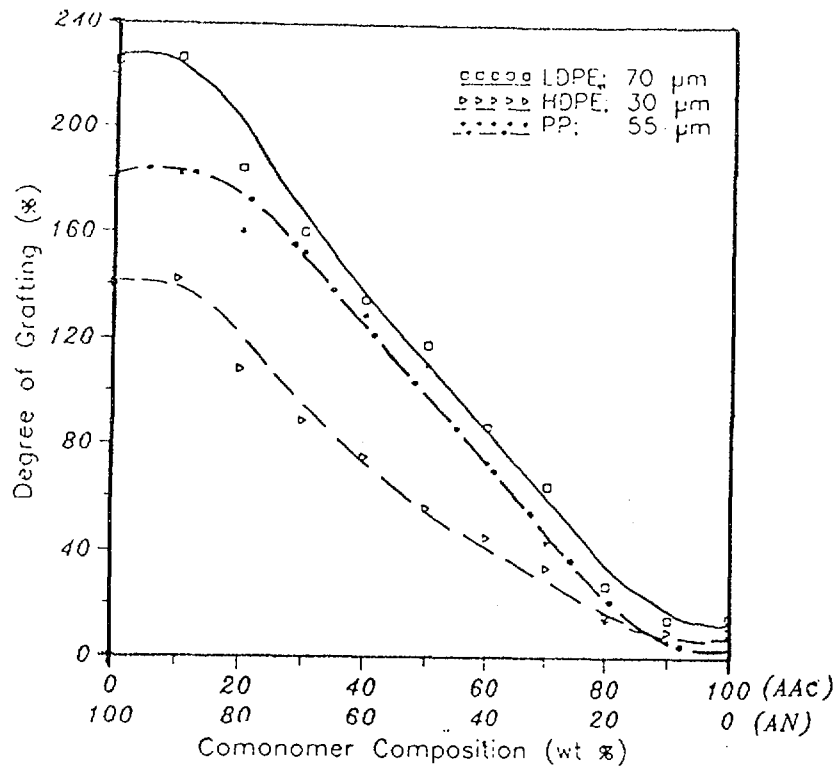


Fig.(1) Effect of comonomer composition on the degree of grafting of (30 wt%) AAc/AN in H<sub>2</sub>O/DMF (30/70 wt %) in the presence of 0.5 wt% CuSO<sub>4</sub> and 3 mole % HCl.

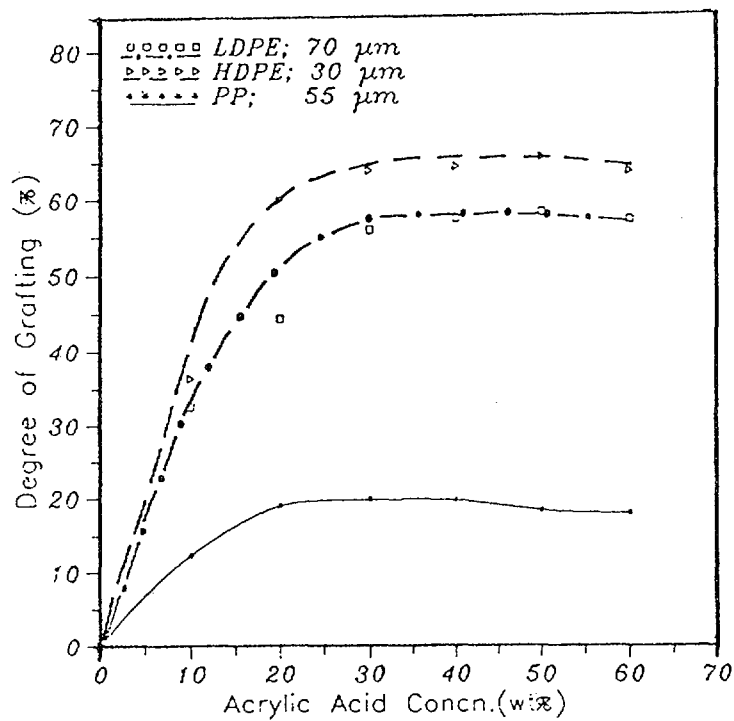


Fig.(2) Effect of monomer concentration on the degree of grafting of aqueous AAc (30 wt%) in presence of 0.5 wt% CuSO<sub>4</sub> and 3 mole % HCl.

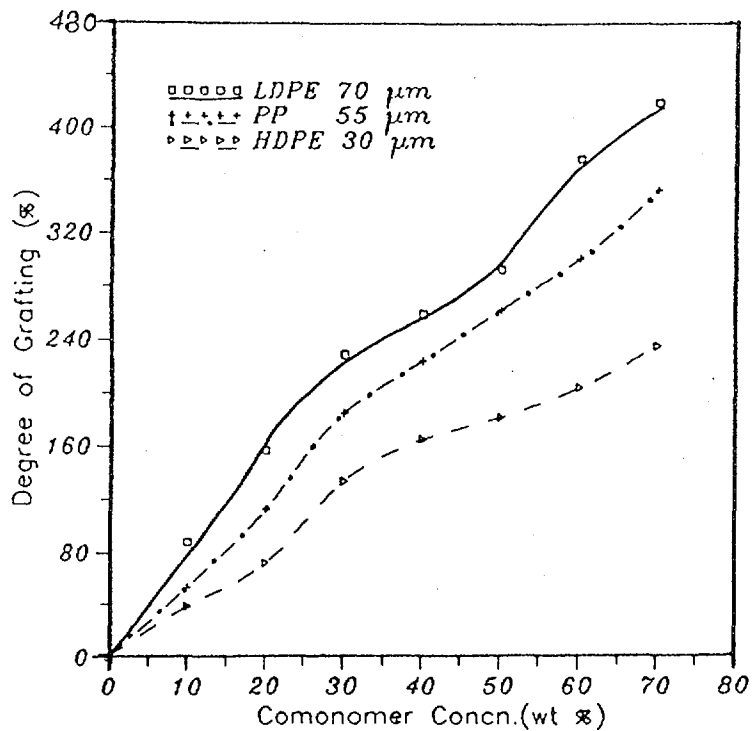


Fig.(3) Effect of AAc/AN concentration on the degree of grafting in H<sub>2</sub>O/DMF (30/70 wt %) at AAc/AN composition (10/90 wt %).

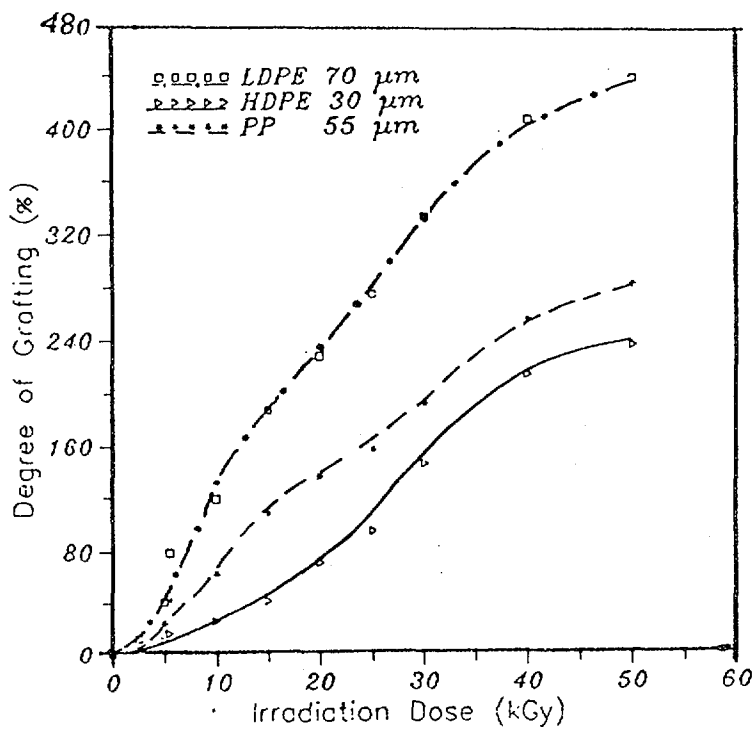


Fig.(4) Effect of irradiation dose on the degree of grafting of AAc/AN (10/90 wt %) of concentration 30 wt % in H<sub>2</sub>O/DMF (30/70 wt %) as diluent in presence of 0.5 wt% CuSO<sub>4</sub> and 3 mole % HCl.

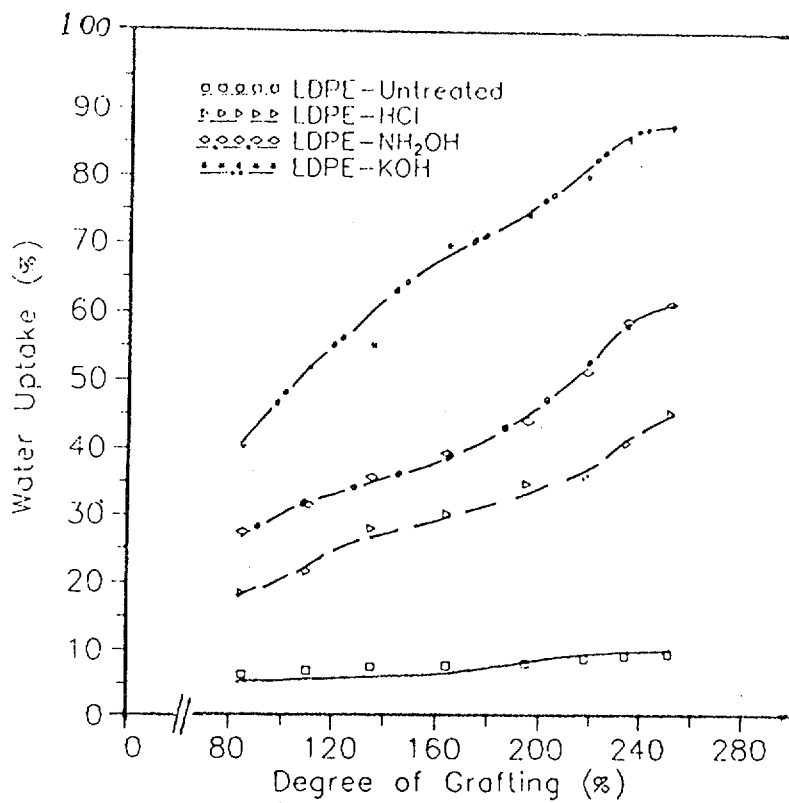


Fig.(5) Effect of degree of grafting on water uptake for untreated and treated LDPE-g-P(AAc/AN) films.

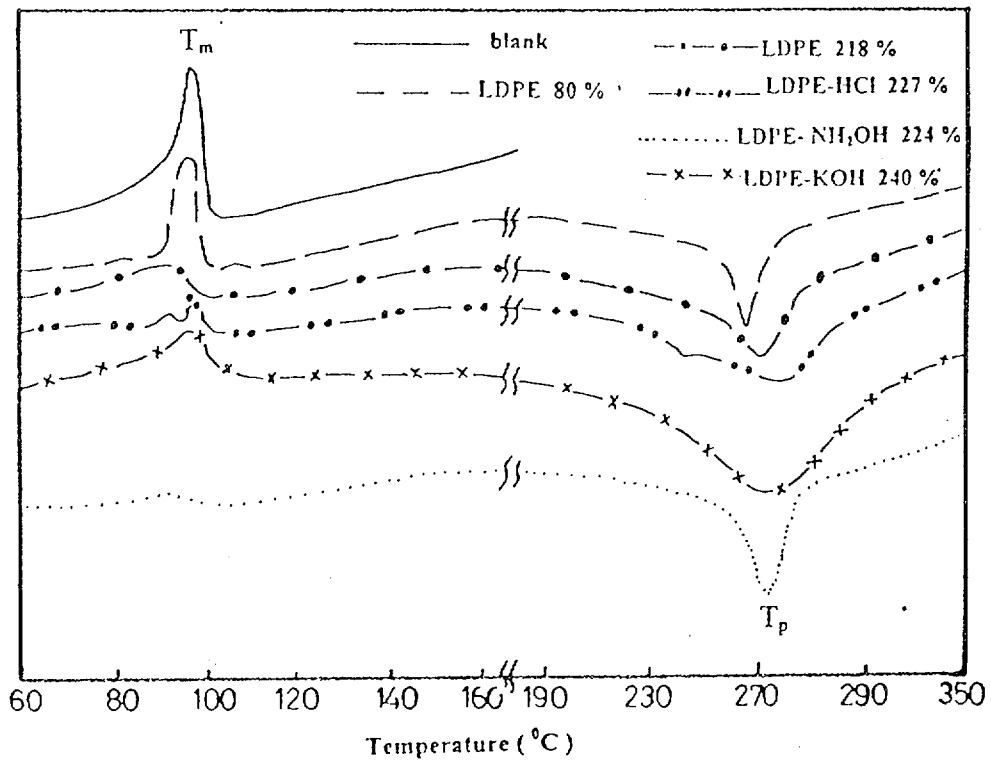


Fig.(6) DSC scan for blank, untreated and treated LDPE-g-P(AAc/AN).

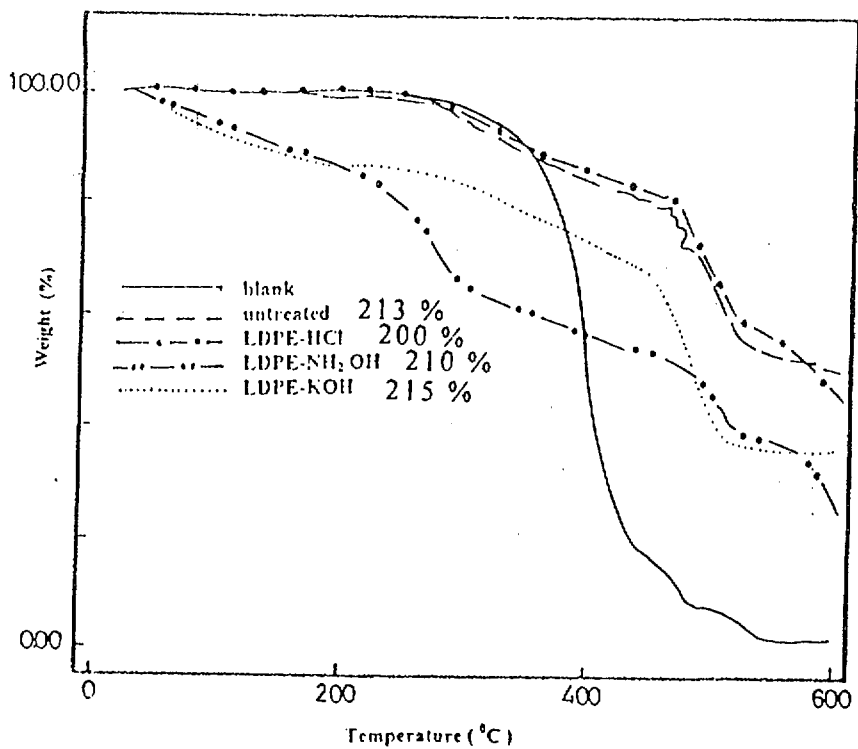


Fig. 7 (a)

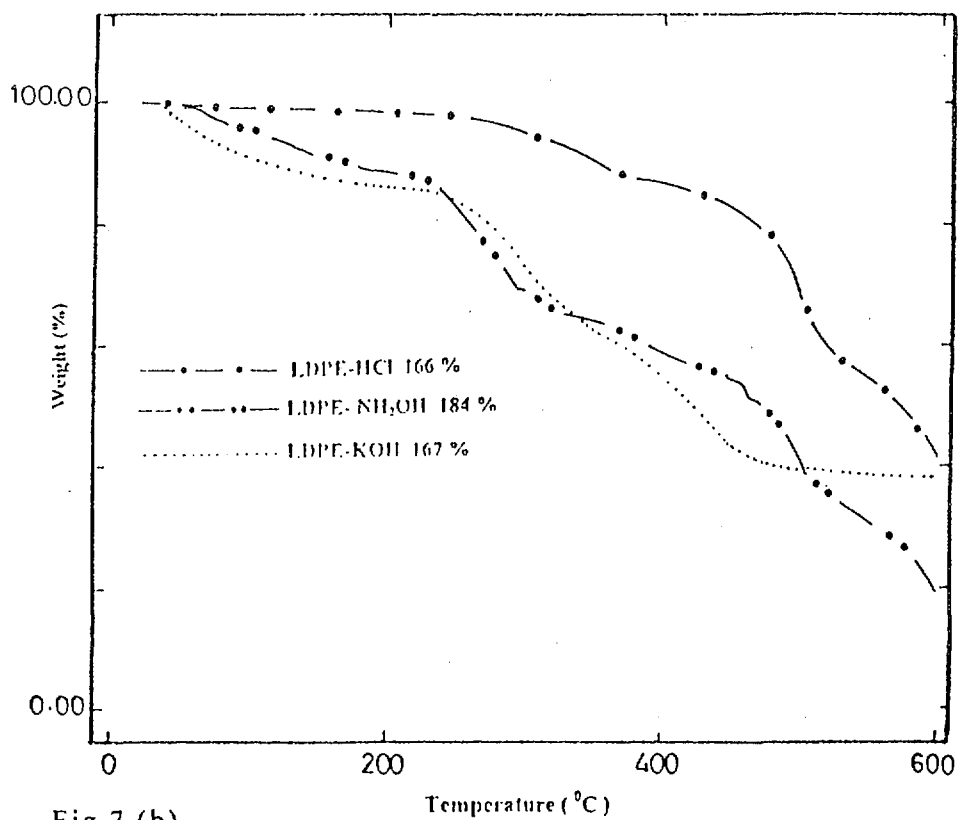


Fig. 7 (b)

Fig. 7 (a,b) TGA thermogram for blank, untreated and treated LDPE-g-P(AAc/AN)