The Effect of Neutron Irradiation on the Electrical and Optical Properties of Polypyrrole

S.J.Abbas, Ammar A. Al-Saad, A. Shawi

Abstract:

The electrical conductivity and absorption spectrum of polypyrrol conductive polymer exposed to a different neutron doses have been studied.
Remarkable changes in its conductivity and absorption spectrum have been observed.
The neutron induced changing in the bond length and alterations in the molecular structure have been suggested to explain these observations.

Introduction

Over about twenty years ago, since the discovery of conducting polymers[1], Intense researches had been worked out in these polymers to explain their unusual electrical,optical,etc.,properties[2-5].
The unusual property arises from different aspects:
1- The special nature of the charge carriers (soitons, polarons, bipolarons).
2- The intrinsic electronic and optical properties of highly doped conjugated conductive polymers are metal like (small positive thermopower, a high and Temperature independent pauli susceptibility, free carrier absorption),..etc.[6,7].

Although, the changing in the properties of the conductive polymers in many cases are considered as a drawback of those polymer systems ,but, in other field these changing can be used as a sensors during the reaction of the conductive polymers with a various redox agents (dopants) or via their instability to moisture, heat, and radiation,....etc.[8,9] .

In previous studies, it found that the electrical and optical properties of polyacetylene and polythiophene changed by electron irradiation with the presence of SF_6[10,11].The changing explain by (1) formation of an effective charge transfer,(2) formation of cross linking between neighboring chains,(3) electron beam assisted doping of either the SF_6 molecule or some of its decomposed fragments .

In this study ,we will report the effects of neutron radiation on the electrical conductivity and the optical absorption spectrum of polypyyrol polymer.

Experimental

1- Electrical conductivity measurements: We used two free standing film from polypyrrole .These films prepared by the electrochemical method, using one compartment cell with two electrodes, a pt as a cathode, and stainless steel as anode.
The details of the preparation method is described elsewhere[12].

One of these films exposed to neutron radiation for different times, and another one left in air. The conductivity is measured by simple two probes method, since, we used old films, their conductivity is low comparing with as grown-films.

2- Optical absorption : The films used hair is prepared by the same method described in part (1), but the polypyrrol film deposited on the semitransparent slide alas coated with thin layer of Ni metal . The optical absorption measurements were carried out with double beam pye-Unicam SP.8-500 spectrophotometer which cover the range from 340 nm to 900 nm .
All measurement worked out at room temperature.

3-Neutron irradiation : The irradiation of polypyrrol films was done by Am-Be neutron source (supplied by Amersham/England). The neutron source was a cylinder of a dimension 6 cm in height and 3 cm in diameter and the emission rat of neutron from this source was $1.1*10^7$ n/s as given by the supplier.

Results and Discussion

Figure(1), shows the change of the electrical conductivity of two samples of polypyrrol , one of these films exposed to neutron for a different times, and the other is left in air .

As well appears from the figure the conductivity increases with neutron irradiation time to a certain time and then decreases, while the conductivity of the sample that left in the air was unchanged .Figure (2), shows the optical absorption spectrum for polypyrrol transparent film under a different neutron irradiation times, from this figure , we observed , there are a decreasing as the irradiation time increase, no remarkable change have been observed in the peak value (peak position) . The optical density versus irradiation time for three wavelength plot in figure (3).

There are similarities between the behavior of the electrical conductivity and optical density with irradiation time. The factors that effect on the properties of the polymer, for example, temperature, carrier concentration, type of dopant, humidity, light are constant here. The effect of oxygen is into account in the present work. As shown in figure(1), the oxygen has no significant effect on the conductivity. So the only factor that effect on the properties of the polymer under study ascribed to the neutron irradiation.

The polypyrrol doped with (ClO_4^-) contains of C , H , N and ClO_4 . The neutron interact with nuclei of the element by a different kinds of reaction and the most probable reaction of the Am-Be neutron (their mean energy= 4.5 MeV) with the above mentioned nuclei was elastic scattering[13].

By the elastic scattering, a part of neutron energy was transferred to the recoil nuclei, and the most of the neutron energy will be transferred to the hydrogen nuclei because of the equality of there masses with that of neutron approximately.

So, the most probable of neutron energy in the properties of polypyrrol after the neutron irradiation may ascribed to there scattering with hydrogen nuclei which leads to breaking the bond and ionized the hydrogen atoms and rearrangement the molecular linking ,or shortening and lengthening the bonds between hydrogen and other elements, or between chains of polymer .

Take into account, the above concepts, we conclude the most probable mechanisms take part to increase the conductivity and intensity are:

1- The shorten and lengthen the bonds resulting the displace the nuclei (H-atoms) via

Reaction with neutron.

2- Crosslinking formation between polymer ionized chain.

3- Change in molecular geometric (rearrangement) which may leads to polymer more oriented or lead to decreasing the vacancies and therefore less light scattering[14].

On the other hand, decreasing in conductivity and intensity after certain irradiation time because of the large neutron flux causes to destroying the polymer structure , bonding , and shortening the conjugation length .

Although the previous conclusions are macroscopic observations, but consent with measurement carried out in our experiments, and agreement with other explanation suggested after other authors[10,11].

References

1- H. Shirakawa, et al. , J.Chem. Soc. Chem. Comm. , 16 (1977) 578 .

2- I . Skotheim, "Handbook of conducting polymers" NY. Marcel Dekker , 1986.

3- J.M. Margolis,"Conductive polymer and plastic ", 1989.

4- R.W. Dyson, "Specialty polymers" Chapman and Hall, NY ,1986.

5- J.I. Kraschwitz, "Electrical & electronic properties of polymers ", John Wiley & Sons, INC, 1988.

6- H.Stubb , E. punkka and J. palaheimo, Mat. Sci. Eng. 10 (1993). 85.

7- W.R.Salaneck, Contemp. Phys. 30 (1989) 403 .

8- See Refs. 3& 4 .

9- K. Kaneto, S. Takada, and K. Yoshino, Jpn. J. Appl. Phys. 24 (1985) 1553 .

10- K. Yoshino, et al. solid stat commun. 46 (1983) 405 .

11- K. Yoshino et al., Jpn. J. Appl. Phys. 23 (1984) L189 .

12- S.J. Abbas, M.s. Thesis, Univ. of Basrah, Basrah,Iraq 1993 .

13- Handbook on nuclear data for bohole logging and mineral analysis . Tech . Rep . Series No.357 , IAEA, Vienna, 1993.

14- B.O. Seraphin, Optical properties of solids , New Developments, North-Holland publishing company, 1976 .

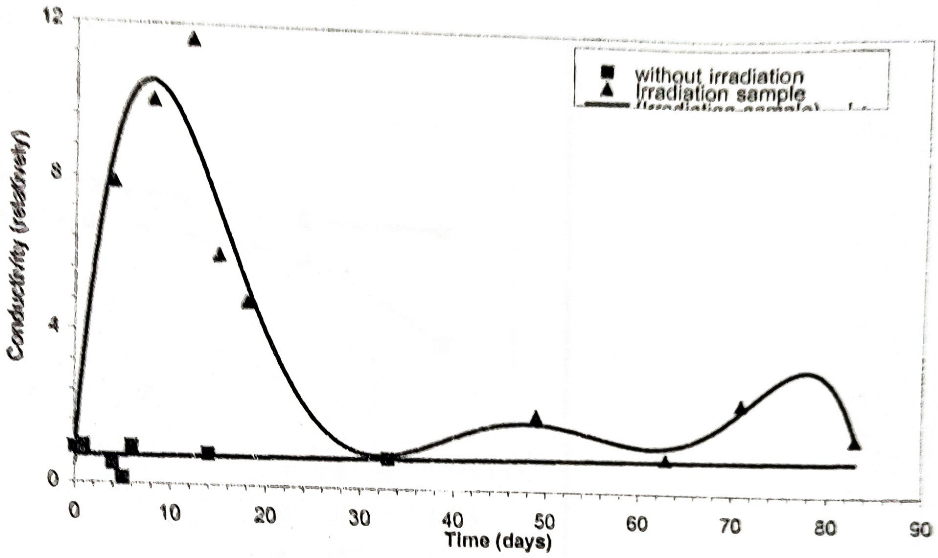

Fig.(1); The conductivity of PPY(ClO)

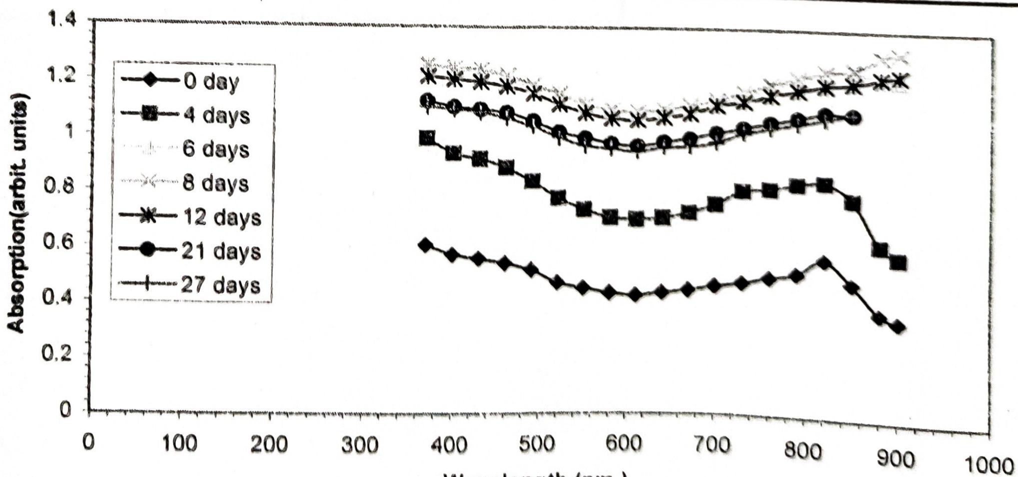

Fig.(2): The absorption spectrum of PPY(ClO) at different neutron irradiation times

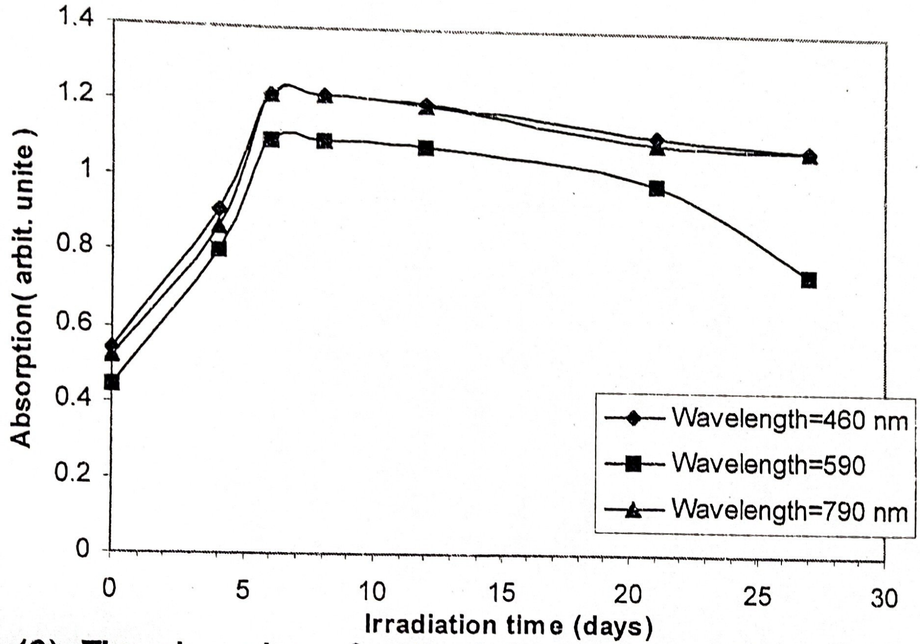

Fig.(3): The changing of optical absorption of PPY(ClO)film with neutron irradiation time at different wavelength