Analytical Detection Methods for PVC Thin Films Degradation Containing Different Concentrations of Diphenylenehydramine

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Abstract:

The head to tail structure of normal PVC should be quite stable to UV radiation. However, the presence of polymer chains abnormalities in the responsible for the relative instability of PVC to light. Therefore, many attempts have been taken to investigate and elevate the photostability PVC. In this work, diphenylenehydramine compound had been used as a photostabilizer to PVC films with different concentrations and its efficiency was evaluated by weight loss percentage, carbonyl index methods after 60 hour of irradiation and surface morphology of PVC.

Keywords: Poly(vinyl chloride), Diphenylenehydramine, Photostabilizer, UV radiation, carbonyl index.

Introduction:

Poly(vinyl chloride) is the second of the polyethylene among the highest sales plastic kinds materials, which are widely utilized in a wide range of industries containing, packaging, electronics, architecture and transportation(1). While, PVC low photo-stability produces to the loss of hydrogen chloride, color change, and lastly the serious corrosion phenomenon, accompanied by variations in the chemical and physical characteristics of PVC(2). PVC products acceptance for external uses builds on their ability to inhibit photodegradation over long periods of exposure to sunlight(3). To guarantee the ability of weather, we needs to enhancement of PVC and processed properly with appropriate additives, producing to a complex material that's a quite different behavior and characteristics from those of PVC resins themselves(4). Poor PVC stability prevents its use in outdoor applications. This degeneration can be inhibited by using stabilizers to enable the using of the polymer in harsh conditions. Commercial
stabilizers can be used to promote the stability of the polymer (5). Photostabilizers Schiff base complexes including (6-8), aromatic compounds (9-13) and heterocyclic(1) have been investigated in various studies for increasing PVC stability. The aim of the proposed work is to study the ability of diphenylenehydramine compound to reduce photodegradation effects on PVC films, by mixing various concentrations of diphenylenehydramine with PVC film (40 µm thickness) and observe the most efficient concentration in resisting the photodegradation upon 60 hours of irradiation.

Materials and Methods:

Chemicals

All chemicals were supplied by (Sigma Aldrich, United Kingdom) and have been utilized without further purification. PVC (degree of polymerization 800, resinK value 67) was supplied by (Petkim Petrokimya, Turkey).

Preparation of the Films

The PVC films were prepared by mixing with diphenylenehydramine of several concentrations (0.1-0.6%) by weight of (40 µm thickness) in THF as a solvent. The solvent was left at room temperature to evaporate for 24 hour.

Exposure to light

Irradiate PVC films had been used UV light of (light intensity value = $7.75 \times 10^{-7}$ ein dm$^{-3}$s$^{-1}$ and $\lambda_{\text{max}}$=320nm) utilizing accelerated weather-meter Q.U.V tester (Philips, Germany). Films continued to be irradiated for 60 hours at room temperature.

Determination of photodegradation of PVC membranes by FTIR spectroscopy

The PVC prepared films measured FTIR spectra before and after 60 hour of irradiation by FT-IR8300 Shimadzu spectrophotometer (4000–400 cm$^{-1}$). Growth of certain bands upon time of irradiation had been observed, such as carbonyl group band which can be observed at 1722 cm$^{-1}$. Carbonyl index ($I_{C=O}$) had been calculated by using the equation 1(14):

$$I_{C=O} = \frac{\Delta A/A_t}{\Delta t}$$  \hspace{1cm} (1)

The Percentage of Weight loss Determination by photodegrade prepared PVC films

The weight loss Percentage for prepared PVC films calculate through irradiation process by used the following equation (2):

...
Weight loss Percentage = \( \frac{(W_1-W_2)}{W_1} \times 100 \ldots (2) \)

\( W_1 \) refer to PVC film weight before irradiation; \( W_2 \) refer to PVC film weight after irradiation.

**Result and discussion**

Fourier-transform infrared spectra for PVC prepared films with the additive (diphenylenehydramine) (figure 1) measured against irradiation time.

![Diagram of Diphenylenehydramine](image)

**Figure 1.** Structure of Diphenylenehydramine.

PVC film (blank) utilized to follow the process of photodegradation during irradiation time. Photo oxidation of PVC production of different fragments (15), the most abundant ones are Ketones and chloroketone carbonyl group (C=O) (Fig. 2). But, the abundance of these functional groups is lower compared to those for ketone fragments (15). In FTIR spectra noticeable that a changes in peak intensities of PVC carbonyl group after irradiation to those before irradiation. The spectra of FTIR appeared that the absorbance of a functional group (carbonyl group) were increase as a result of the irradiation process which can be used as a method to monitor the photodegradation and the effectiveness of the additive. The absorption band observed at 1722 cm\(^{-1}\) which could be assigned for (carbonyl) (16). The changes in carbonyl \( I_{CO} \) were investigated against irradiation time to study the stability of PVC films containing different concentrations of (diphenylenehydramine) as during irradiation as shown in Fig. 3.

The FT-IR spectra of (40 \( \mu \)m thickness PVC prepared films) in the presence and absence of the additive diphenylenehydramine as percentage of the weight used) an additive before and after irradiation (60 hrs) are shown in Fig. 2. The figure shows the effectiveness of the additive drug name to reduce the effect of irradiation by comparing the growth of in carbonyl index of PVC blank film with PVC films containing different concentrations of the diphenylenehydramine. The results have shown that the percentage of (PVC + 0.4% L) was the most effective compared to the others.
Figure 2. FTIR spectra for PVC with diphenylenehydramine before and after 60 hrs of irradiation.

Figure 3. Changes in $I_{CO}$ against irradiation time for PVC films.
Percentage Weight loss % Photodegradation of prepared PVC Films

The PVC photodegradation degree can be calculated by the percentage weight loss of PVC after irradiation by use equation(2)(17). Fig. 4 shown the irradiation time affected on percentage weight loss for prepared PVC films, the Percentage weight loss was lower in PVC films in the presence of diphenylenehydramine as a photo stabilizer with different weight percentages compared to PVC (blank) film. The PVC film with 0.4% of diphenylenehydramine (PVC+0.4%L) was most effective because it could act as a radical scavenger effectively, given its proximity to optimal weight(0.5%).

Surface Topography of PVC film

The surface topography gives information about the surface roughness, irregularity and defects in polymer materials(18). It can reveal the changes in the surface of the polymer when added where degradation occurs as the chain does not have a good chain fragmentation(19). Fig. 5 has shown the compared between PVC films morphology images before and after irradiation time (60h) to PVC pre-irradiation (blank) film, surface image appear that presence of cracks, fluting and white spots after exposure to radiation. The surface of (PVC+ 0.4%L) film was smooth and has a few white spots.
Figure 5. Microscopic images of PVC+ (0.1-0.6)%L before and after irradiation process.
Conclusion
diphenylenehydramine compound has been used with different concentrations as effective photo stabilizers of poly(vinyl chloride) and its efficiency was evaluated by weight loss percentage, carbonyl index methods after 60 hour of irradiation and surface morphology of PVC.

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