AL-Qadisiya Journal for science Vol. 15 No. 2 year 2010

The Adhesion of HDPE and LDPE to Copper and the Use Peel Test to Study the Strength of Adhesion Bonding

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ABSTRACT:-

The peel test has been used to study the adhesion achieved between a high – density polyethylene (HDPE) and low – density polyethylene (LDPE) to copper by inserting in the molding steel die. The parameter employed to evaluate the efficiency of the adhered polymer to metal was the peel force. The peel force (F/b) was taken as the load per unit length during peeling. Adhesion efficiency represented by peel force in thermal oxide is generally low as the oxide is brittle and easy to fracture and in the chemical formation of matt black surface on copper , the (LDPE) exhibit higher adhesion efficiency than(HDPE) for the same surface pretreatment.

INTRODUCTION:-

Polyethylene to copper adhesion is a widely used process, important in the protective coatings for corrosion prevention and industrial application. When polyethylene is used as a hot melt adhesion, better bond strengths are achieved with oxidized polyethylene then with unoxidized [1]. Many studies of the adhesions of PE to metals have found good adhesion is associated with conditions with conditions where the polymer can oxidize [2].

Adhesion of polyethylene to copper is generally poor. Bright and Malpass[3] ascribed this to the copper's inhibiting oxidation of the polymer. Much higher adhesion, however, can be obtained with copper if the metal is oxidized prior to bonding to give a thick mutt black surface oxide. It was previously considered that the origin of good adhesion was oxidation of the polymer by CuO oxide in the film [4].

Earlier work in laboratories on the heat treatment of polyethylene melt coatings on metals attributed improved adhesion obtained at room temperature on quenching the coating from the melt to increased toughness of the polymer itself [5].

EXPERIMENTAL METHOD:-

In order to obtain the desired polymer adhered metal samples, it was necessary to fabricate a steel die that can be easily dismantled after each run, with outer dimensions120×25×22 mm, and inner base cavity area for molding was 80 ×20 mm. This cavity corresponds to the same area of metal strips when it is inserted .

Compression molding of polymer was performed on an electrically heated press A7685 British product. The platens of the press were heated to a temperature close to the polymer melt temperature and the platens were brought together by hydraulic jack via a pressure of 10 bar. The individual copper cut strips for the oxidation studies had a total surface area of approximately 34 cm^2 and a weight of 13.8 g . In order to obtain clean copper surface, it was necessary to remove any contaminated layer such as cutting work pieces, greasing and oxides. The cut pieces were first edge freed from burrs, then followed by polishing process through 300grade metallographic paper.

The samples of copper were washed with dilute hydrochloric acid to remove the oxide followed by a wash distilled water and acetone. The samples were degreased in trichlorethylene Cl_3C_2H (MW 131.39 g/mol) for 10 minutes. They were next chemically polished by immersion for 10 minutes at room temperature in a solution consisting of :

60 ml orthophosphoric acid
30 ml acetic anhydride
8 ml distilled water

and finally rinsed with water and acetone.

Peeling Test

This test was designed to assess the strength of adhesion bonding between polymer metal interface according to ASTM D1876 − 72[6]. The test pieces were those prepared as described. The test was conducted on INSTRON universal testing machine type 2211 for the measurement of the peel force at a constant cross head speed of 1mm / min and peel angle of 90º with the aid of a suitably designed Bell peel fixture to grip the polymer–metal strip in the INSTRON machine.

RESULTS AND DISCUSSION:-

The parameters employed to evaluate the efficiency of the adhered polymer to metal were the peel force [7]. The peel force (F/b) was taken as the load per unit length during peeling .

Adhesion of HDPE and LDPE to Copper

1- HDPE-Cu

The peel force obtained for the adhered HDPE to copper at the oxidation temperatures 90,250 and 800 ºC are plotted versus peeling distance under different oxidation times of 30,60,90 and 120 minutes as shown in Fig. (1).

From these figures, the highest average peel force attainable of the onset and over the entire peeling distance is 0.32 ± 0.04 N/mm. This value corresponds to a temperature of 250 ºC, an oxide gain of µg/cm^2 and an oxidation time of 120 minutes.

2- LDPE-Cu

The peel force obtained from the adhered LDPE to copper under different oxidation time and temperature are shown in Fig. (2).

In this case, the highest average peel force attainable at the oxidation temperature of 90 ºC and oxidation time of 90 minutes is 0.82 ± 0.06 N/mm. It is evident that the peel force in LDPE case is about 2.5 times larger than in LDPE, which reflect higher adhesion of LDPE to copper.

The matt black formed on copper surface in the chemical oxidation at 90 ºC has a rough surface nature. It was previously considered that the origin of the good adhesion. This result is agreement with the topographic nature of the copper surface, which is reported in reference [4].

CONCLUSIONS

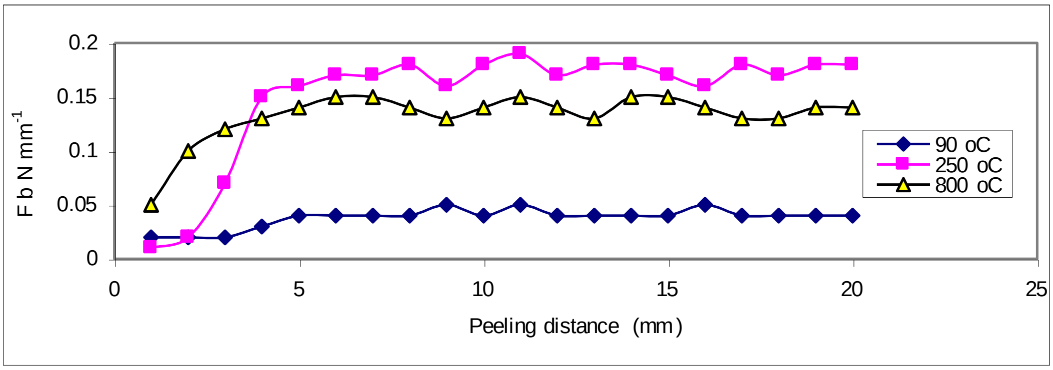
From this investigation the main findings in the adhesion of LDPE and HDPE to copper can be concluded in the following:

1- Adhesion efficiency represented by peel force or peel strength in thermal oxide is generally low as the oxide is brittle and easy to fracture possibly through the boundaries of CuO / Cu_2O phases.

2- The good adherence of thin thermal oxide formed at 250ºC does not reflect a change in the peel strength of either LDPE or HDPE.

3 - Thin thermal copper oxide layer provides better still peel strength than thick oxide layer for the same polymer possibly due to the oxide layer forming single phase Cu_2O.

4 - In the chemical formation of matt black surface on copper, the LDPE exhibit higher adhesion efficiency than HDPE for the same surface pretreatment .



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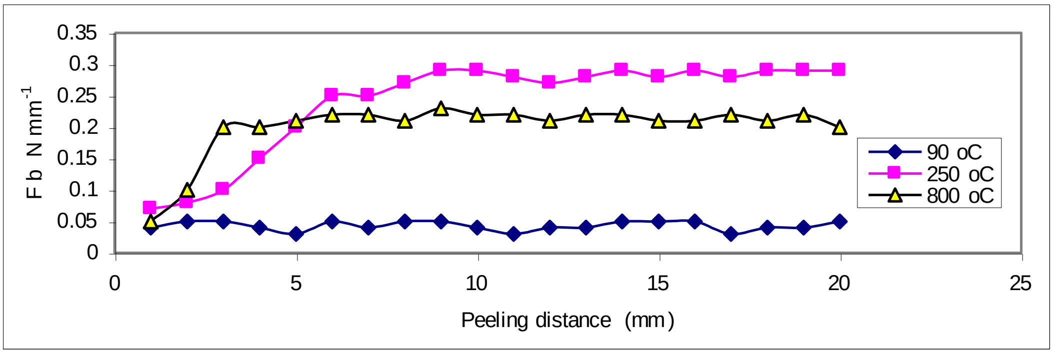

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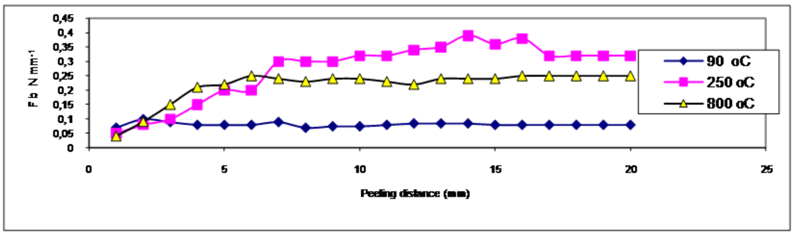

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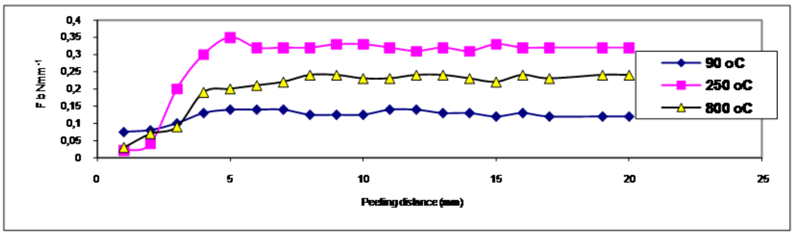
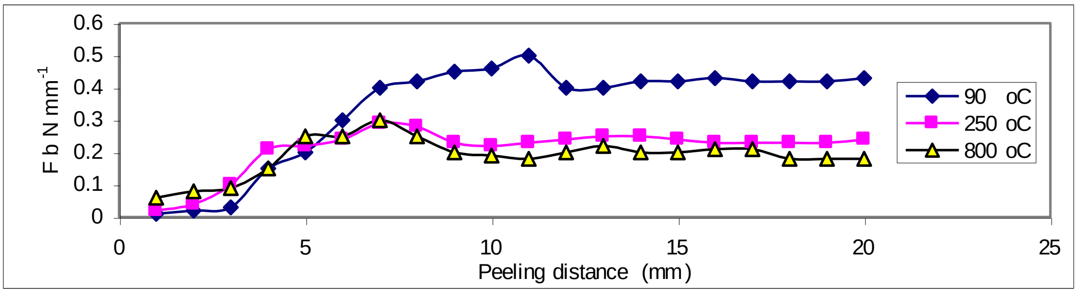
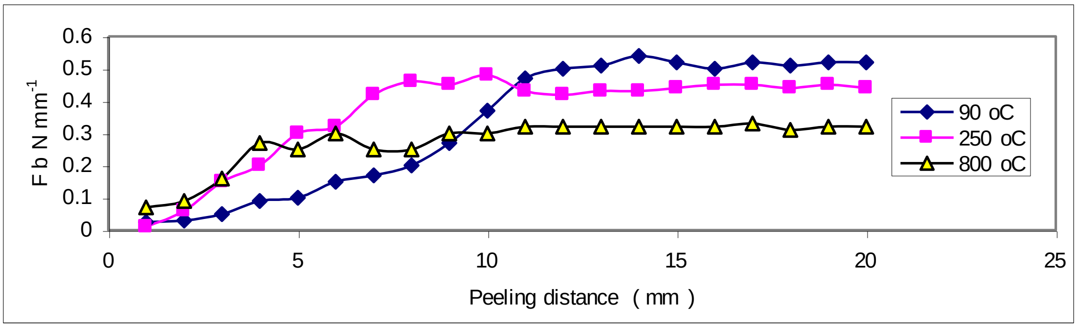


(d)

Fig.(1) Peel force of HDPE peeled from oxidized copper at 90 ,250 and 800^{o}C for: (a) 30, (b) 60, (c) 90 and (d) 120 minutes



(a)



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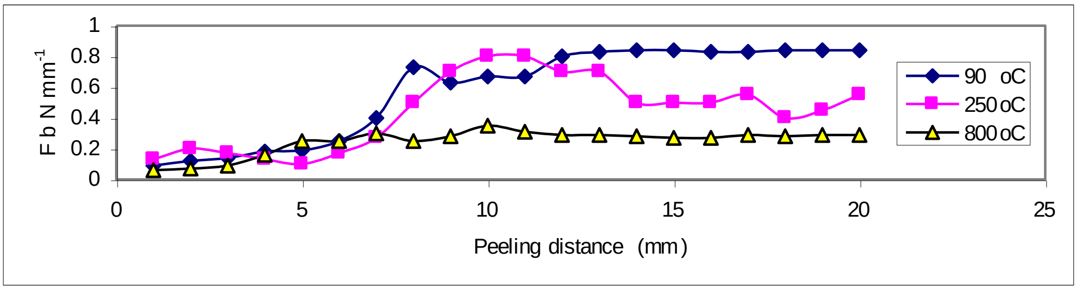

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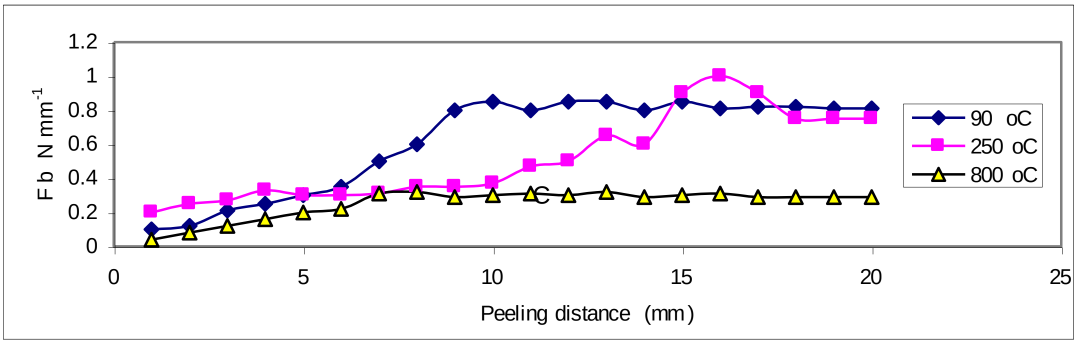

(d)

Fig.(2) Peel force of LDPE peeled from oxidized copper at 90, 250 and 800°C for: (a) 30, (b) 60, (c) 90 and (d) 120 minutes.

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الخلاصة:-

استخدم فحص السلخ (Peel test) في دراسة التصاق البوليمرات (البولي اثلين عالي الكثافة HDPE والبولي اثلين الواطئ الكثافة LDPE) مع معدن النحاس في قالب من معدن الفولاذ .تبين إن كفاءة الالتصاق بين البوليمر والمعدن للحصول على قوة السلخ (F/b) للعينات المؤكسدة حراريا اقل من العينات المؤكسدة كيميائيا بسبب طبيعة سطح الاوكسيد الحراري الهش وسهولة كسره ،وظهر من خلال البحث أيضا إن البولي اثلين واطئ الكثافة يعطي كفاءة التصاق أعلى من البولي اثلين عالي الكثافة بسبب طبقة الاوكسيد الكيميائية على سطح معدن النحاس.