Mechanical Properties of Poly vinyl Chloride/ Egg Shell Composite

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Abstract:

This study summarizes the effect of egg shell particles on mechanical properties of poly vinyl chloride as a function of the filler concentration. Egg shell particles are added to PVC in different concentrations (5, 10, 15, 20 and 25) %wt. The five concentrations of egg shell powder are processed using the same thermo mechanical conditions. The mechanical properties of loaded film have been evaluated through several parameters concerning the elastic deformation based on measuring the load–elongation characteristics. No experimental difficulties appeared for all mixing ratio. The behavior of stress - strain curve is analyzed in terms of cold drawing model. Tensile at yield, toughness, proportional limit and elongation are suffering from a rapid decrease with increasing filler concentration above 15% due to non homogeneity in PVC loaded with different ratios of filler. Also the obtained results show that 15 % of filler concentration is the saturation value. The obtained results are explained in terms of the crack propagation and finally the filler contribution is reducing the cost.

1- Introduction:

Poly vinyl chloride (PVC) is a low cost commodity polymer that is used in a wide variety of applications. PVC is also considered as one of the most widely used among all plastics. With the resin mixed with stabilizers, lubricants, fillers, pigments, and plasticizers, a wide range of properties is possible from flexible to hard types, in transparent, opaque, and colored forms. It is tough, strong, has good resistance to chemicals, good low-temperature characteristics and flame-retardant

ISSN-1994-697X

properties where the ability of PVC to perform such diverse functions is due to the ability of PVC to incorporate various additives to suit the numerous applications (1-3).

PVC is still the plastic with the highest filler usage, followed by polyolefins, nylons, and polyesters (4).On the other hand when a filler is added to a polymer the modulus of the resulting composite will be a function of the module of the individual components, their concentration in the matrix (by volume), and the shape of the filler particles.

Yet a mineral filler will produce a larger increase in modulus if it has a high aspect ratio,(average equivalent diameter of the talc particle divided by its average thickness)(5-8).Ideal fillers own physical properties including good strength to weight ratio,good wetting properties,inflammable,chemical resistance,thermal insulator,controlled grain size and good diffusion properties (9).

Additional growth in the usage of functional fillers will undoubtedly stem from the current efforts towards identifying new applications for composites containing nanofillers(10-11),developing composites containing ultrafine particles (dimensions <3 μm)and the increased usage of natural fiber (flax, wood) composites. Currently, nano-sized fillers have been an attractive approach to enhancing polymers properties. Composites materials based on nano-sized fillers,the so-called nanocomposites are presently studied especially because they may have unusual combinations of properties (12-14). The present paper summarizes the obtained results of mechanical properties of (PVC-Egg shell particles) for different doping weight percentages (2.5% -25%). Parameters such as elongation, proportional limit, young modulus, stress at yield and toughness, also how the chemical structure of the filler affect the performance of the PVC it used in are also studied.

2- Experimental procedure :

Egg shell particles are used as a reinforcement to enhance the mechanical properties of poly vinyl chloride. PVC (Spenyl SCC – 676) is supplied from the state company for petrochemical industry (SCPI) of (density = 0.922 320.Bulk density= 0.45 g/cc and K value = 65.6-6) loaded with the plasticizer materials (Di-octal- nephthalate)and (IRGASATB-C 230). Egg shell is obtained from the local market. The average egg shell particle size used in this work is (<75) μm. Five concentrations of filler particles (5%, 10%, 15%, 20% and 25%) wt% are used in the PVC compounds. Table(1) shows the composition of the added filler. Egg shell as a fine powder is mixed with PVC using mixer 600 instrument attached to Haake Rehochard meter under following conditions; mixing time 15 mins, mixing temperature 160^0C and mixing velocity 32 RPM. The plasticizer material of concentration is (15%) and stabilizer material is (1%) in concentration according to the polymer, by using the cross section (mixer 400) with description (16 R.P.M, 60^oC) for (10 min).The final mold product is introduced in a laboratory compress under 5 tons at 175^0C for 3 minutes in a square frame. The pressure then rises

ISSN-1994-697X

gradually up to 15 tons for (6 minutes) and after this period the sample is cooled up to reach room temperature. Samples dumbbell in shape are prepared for measuring the mechanical properties by using instron instrument whit under following conditions: chard speed (10) cm/min and crosshead speed 20 cm/min. The test specimen is positioned vertically in the grips of the device then the grips are tightened evenly and firmly to prevent any slippage. The relationship between the elongation and load is obtained directly from the instrument. All measurements are made according to [ASTM D638 1977] (15).

Table(1) The structure of The egg shell.

Content	Wt%
Calcium carbonate	94
Chitosan polymer	4
Magnesium carbonate	1
Calcium phosphate	1

3- Result and discussion:

The most widely used mineral additive in plastic industry is calcium carbonate. In this study we use the egg shell as functional filler due to its composition which basically consists of calcium carbonate. The basic characteristics of mechanical properties of the solid are usually determined by testing resulting in various deformations versus dependencies, such as the stress-strain diagram. Tensile characteristics (tensile yield strength, proportional limit, toughness and tensile elongation) have been determined from the stress-strain curve. Figure (1) shows the (stress - strain) curve of PVC loaded with egg shell particles measured at a constant rate loading at room temperature. The value of toughness can be assessed from the area under the curve. Tough fracture: substantial deformation prior to breaking after the maximum in the stress-strain plot has been reached, there is a substantial amount of yielding, before the sample eventually breaks. The large yield is due to molecular rearrangement of the polymer in response to the applied stress. Three regions can be distinguished; first is the linear region; second is the yield region; third is the elongation region up to the break. In the first region, (linear region), where the deformation is not very large, Hook's Law is obeyed which is characterizes by the instantaneous and recoverable deformation associated with the bending and stretching the interatomic bonds between the polymer atoms. Also there is no permanent displacement of molecules relative to others. The proportional limit is referred to the highest stress that can be applied with Hook's law. The variation of proportional limits points against filler concentration is shown in figure (2). The increase of the proportional limit in two regions can be distinguished; the first extends to 15 % where increment is obtained and the second region has the boundary (15% to 25%) where the decrease in the proportional limit is the domain behavior. Hence, the first region can reflect the elastic limit region of the polymer,

in which the uniform extension due to stress increases in a constant rate. In the region confined between the proportionality limit and the yield point, the deformation is not instantaneously recoverable. The variation of tensile at yield against the filler concentration is shown in figure (3), where the general behavior is the decrease with the increasing filler concentration percentage. The filler at 25% strongly reduces the tensile at yield due to the heterogeneity of the distribution of filler. After the yield point, the load decreases and reaches a minimum point called a drawing stress, this minimum is followed by increasing the elongation with a nearly fixed stress where the specimen is not deforming none uniformly at a certain specimen cross section.

Both the variation of the elongation and toughness of PVC loaded with egg shell are shown in figures (4) and (5) respectively. This increment in toughness can be referred to increase the resistance of the material to deformation and its ability to resist crack propagation especially at 15 % of filler concentration .Adding more filler above this ratio causes the toughness to be decreased where this decrease may be explained in terms of reducing the resistance to crack initiation by acting as stress concentrators. The obtained results of elongation show that the incorporation of the egg shell filler and of 15 % of the filler leads to an increment in elongation due to the increase in the impact strength and spread of the absorbed energy throughout as large a volume as possible to prevent brittle failure thus we see the increment in elongation at 15 % of filler concentration of high toughness, the decrease relations for the tensile at yield and elongation with concentration of filler above 15% ratio of filler concentration is because of the saturation.

4- Conclusion:

The Stress-Strain relationship in (PVC/egg shell particles) composite is a complex dependence and is not linear in nature. A cold drawing characteristic is obtained for this composite. Less homogeneity is obtained with a high ratio of the filler PVC matrix. Mechanical properties PVC are changed by adding egg shell particles in different weight percentages. It is found that toughness is a function of the particle size and stiffness. The major contribution of fillers is in reducing the cost of materials by replacing the more expensive polymer since the filler costs less than the compound. The more one is added the lower the formulation cost, tensile at yield is not an indication of toughness where tensile slightly decreases as filler is added since the surface coating that help to increase toughness lowers the particle's adhesion to the polymer while tensile elongation is an indication of toughness. Finally the filler must be well dispersed in the PVC matrix during the melt compounding process to break up any agglomerates of the filler or also the physical properties of the compounded PVC will be poor.

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ISSN-1994-697X

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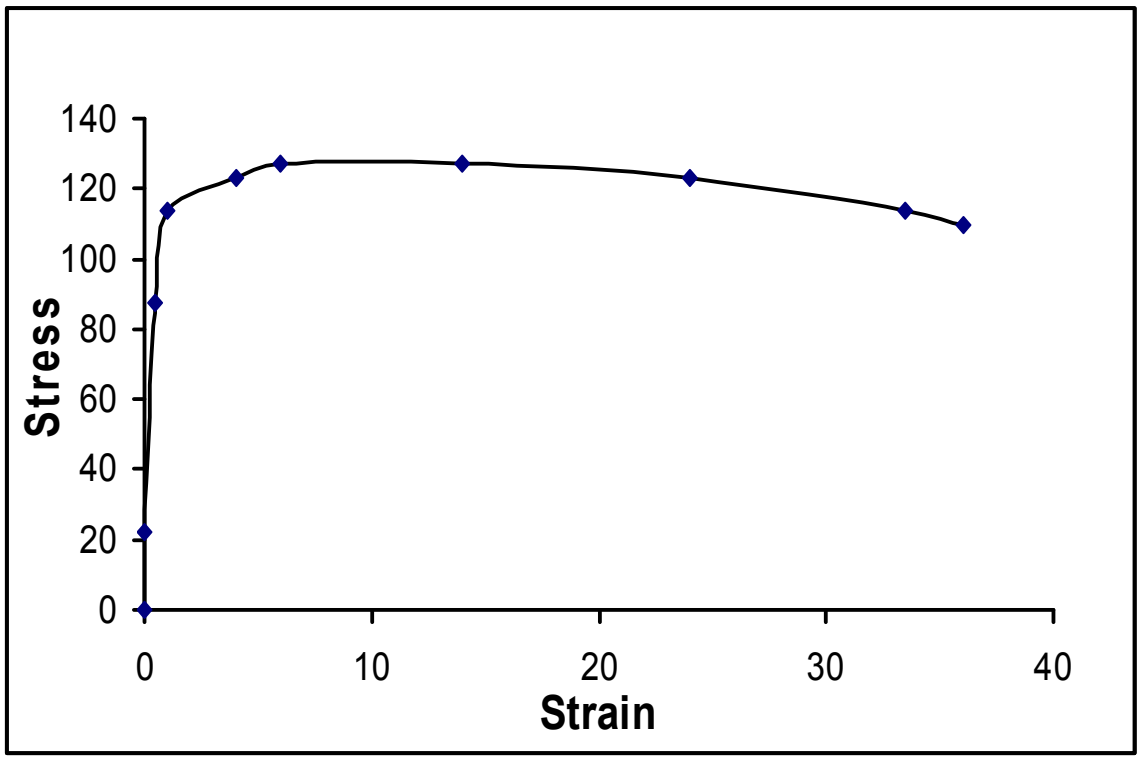
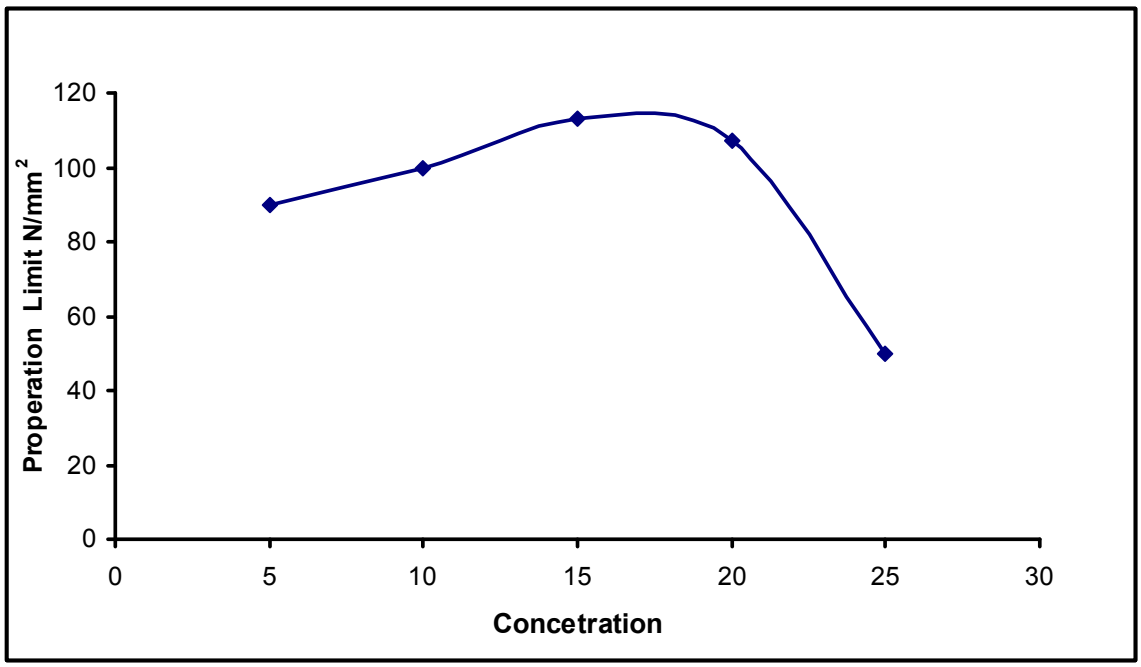
ISSN-1994-697X

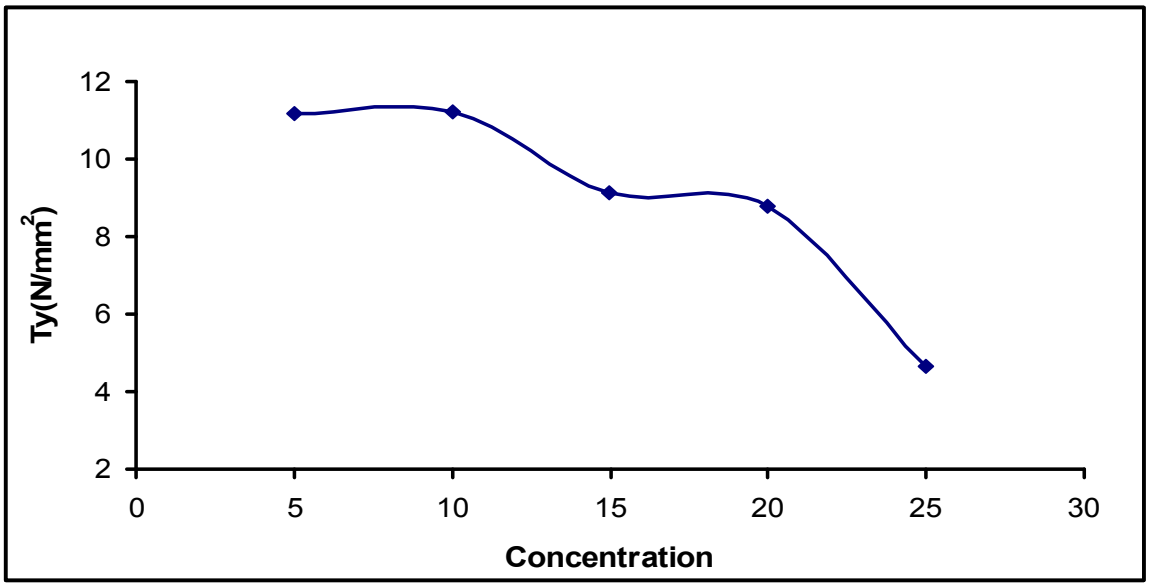


Fig(1).The stress-strain variations.



Fig(2).The variation of proportional limit with concentration.

ISSN-1994-697X



Fig(3).The variation of yield stress with filler concentration .

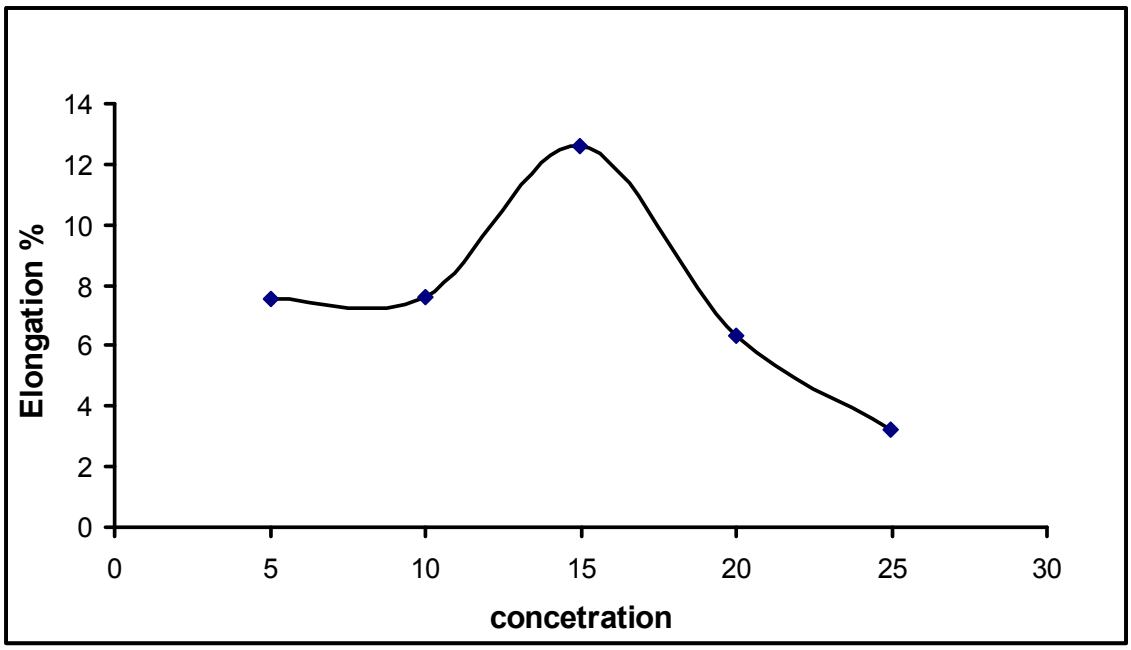
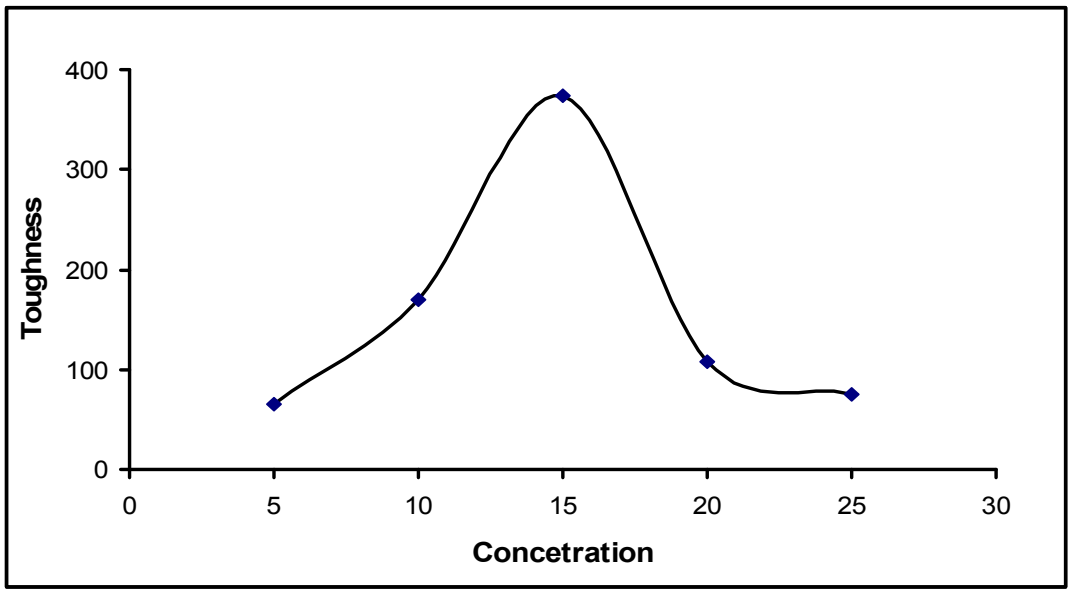


Fig.(4). The variation of elongation with filler concentration.

ISSN-1994-697X



Figure(5).The variation of toughness with percentage elongation.

الخواص الميكانيكية للخليط (بولي كلوريد الفاينيل / دقائق قشور البيض).

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المستخلص :

تم في هذا البحث تقييم الخواص الميكانيكية للخليط البوليمري (بوليمر كلوريد الفاينيل/ دقائق قشور البيض) كدالة الى نسبة المضاف الوزنيه والتي تمتد ما بين (٥ و١٠ و ١٥ و٢٠ و٢٥) % نسبة وزنيه من وزن البوليمر، وتمت عمليه المزج للنسب الخمسة من قشور البيض مع البوليمر تحت نفس الشروط الثرموميكانيكية، ودللت النتائج المستحصلة الى نقصان واضح وكبير في الخواص الميكانيكية لهذا الخليط عند إضافة دقائق قشور البيض وخاصة عند النسب الأكبر من ١٥%، حيث اعتمد مقدار التغير المرن الحاصل في النماذج البوليمرية المحملة بقشور البيض لقياس مميزة (نسبة المضاف–الاستطالة)، وأيضا من خلال حساب عدة متغيرات تمثلت في مقدار الاستطالة وقوة الشد عند الوهن ونقطة حد التناسب والصلادة ومن النتائج العملية المستحصلة أيضا هو عدم ظهور أية معوقات خلال عملية المزج ولكل نسب المضاف، وتم تشخيص منحني الإجهاد – المطاوعة من النوع البارد ودلت النتائج المستحصلة أيضا إن كل من الصلادة والاستطالة وقوة الشد عند الوهن تعاني انخفاضا حادا مع زيادة نسبة المضاف الأكبر من ١٥%، نتيجة لعدم التجانس في توزيع دقائق المضاف بصورة متجانسة داخل المصفوفة البوليمرية وان نسبة الإشباع ألوزنيه للمضاف هي ١٥%، وتم تفسير النتائج بدلالة انتشار التشققات خلال الشبيكة البوليمرية وتأثرها بنسبة المضاف و ان من اهم فوائد المضاف هو تقليل الكلفة .

ISSN-1994-697X