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Evaluation of thermal and mechanical properties of Low-Density Poly Ethylene (LDPE) - Corn Flour (CF) composites

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Abstract : The current research aims to improve the thermal and mechanical properties and water absorption resistance of low-density polyethylene (LDPE) as matrix material. The corn flour (CF) powder weight content in the consistent particle size (300µm) and different weight ratios 5, 15, and 20wt. %. The mechanical measurements such as tensile strength, modulus of elasticity, and elongation at break % were analyzed to compare the effects. The obtained results displayed that the addition 5-20% of CF powder to LDPE led ofraising the tensile strength, modulus of elasticity, and a decrease in elongation at break (%).The results of the thermal gravimetric analysis (TGA) exhibited a significant improvementin thermal stability when adding different concentrations of CF in pure LDPE because interfaces between CF and pure LDPE caused of decreased the brittle behavior and enhanced the high crosslinking of pure LDPE.
Keywords : Mechanical properties. Low-DensityPolyethylene (LDPE), Corn Flour (CF).

Introduction-

A composite is including combine two materials or more and that they are mixed with each other without soluble. In composite materials, one phase is mostly inorganic or natural fillers as adispersed phase in thepolymeric matrix. These fillers have superior mechanical, and chemical properties and enhance the performance of composites.[1-4]Polymeric materials have been widely usedin several applications such as industrial and medical applicationsdue to their excellent chemical, physical, mechanical, and antibacterial properties. Although these advantages, they can cause environmental risks when they are neglected or entombed in the sea or defacing under the soil.[5-7]With the rising concern over environmental issues, the biodegradability of resources is becoming increasingly important. Plastic degradability has been presented as a process to reduce the disposal problems of plastics. One effort has been made to create degradable plastics by incorporating starch into polymers for the production of degradable materials. Corn flour contains between 75 to 87 % starch, 6–8% protein, 2–6% lipid, and 1–4% of cellulosic fibers. It is an essential component of food and a renewable source using in several industrial applications[8-14]. The current work will focus on applying modifications on the properties of pure LDPE by adding different ratios of Corn Flour and enhance the thermal stability and mechanical strength.

Experimental

Materials:

Low-densitypolyethylene (LDPE) was provided from CABIC chemical company, KSA. The corn seeds were collected fresh from Iraq local farms.

Corn Flour treatment

The corn seeds were dried in a microwave oven at 60-70°C for 3to removemoisture. After drying,they were cracked to small species and then passed through a molecular sieve (300micron mesh). The obtained product was collected and weighted.

Prepration CF-pure LDPE composites

LDPE particles were melted and blended with different ratios of CF in a shear mixer at a rate about25rpmwiththecontinued mixing for 7 minutes to achieve the homogenous between the CF and LDPE. The mixture was poured into metal molds, andthe mixture was compressed, starting from 20 kg/cm^3 and then increased to 100 kg/cm^{3}within 7 minutes. After 24hours, the samples were removed from molds and left for a day to make more curing.

Thermogravimetric Analysis (TGA)

Pure LDPE and LDPE-CF composite samples were cut out into small species (5−8 mg), which was then tested by using TGA instruments type (TGA Q500; TA Instruments) under nitrogen atmosphere within a temperature range from 30 to 600°C at a heating rate of 10°C/min. The thermal degradation temperature of composites was tested and followed the degradation of composites within the above temperature range.

Tensile strength tests

Composites samples were tested by using Instron tensile machine model (Testometric, M500-50AT), UK according to ASTM D 638. The crosshead speed was about 20mm/min.

Results and Discussion

Thermal Degradation Analysis of LDPE Nanocomposites

Thermal degradation behavior of the pure LDPE and LDPE-CF composite samples are shown in Figure1, and 2.T_{onset}referred to the initial degradation temperature and is a relevant factor indicating on the thermal stability. [15]The maximum decompositiontemperature T_{max}, T_{onset} and residual yield% at 600°C are summarized in Table 1. The patterns of the curves for the pure LDPE sample are similar to that of LDPE-CF composites samples. From figure.1 and 2, they were observed that the thermal decomposition of samples was decreased with increasing of the CF contents from (5-20%). The presence of the CF fillers is to make more stability of the LDPE matrix and gives higher interfacial adhesion and crosslinking between the CF fillers and the pure LDPE[16,17]. From Table 1 showed that T_{onset}, T_{max}, and residual yield were increasedby increasing the contents of CF.Table 1 indicated thatT_{onset} was about 450.5 °C while T_{onset} of 5, 10, and 20% CF in LDPE were about 475.4, 515.2, and 580.2°C respectively. T_{max} in Table 1 and figure 2 of pure LDPE was 472°C, compared with LDPE-20% CF composites that were about 525.4°C. Table 1 showed that the residual yield % exhibited higher values of 5, 15, and 20 % CF and they were about 18.5, 19and 20.5°C respectively, by comparing the value of pure LDPE that was about 17°C.These values in Table 1 and figure1 proved that CF fillers were activated by the high protective effect against the thermal decomposition and enhanced the thermal stability of LDPE. These indicated that the size of cross-linking of CF is more than the of bond break of pure LDPE.

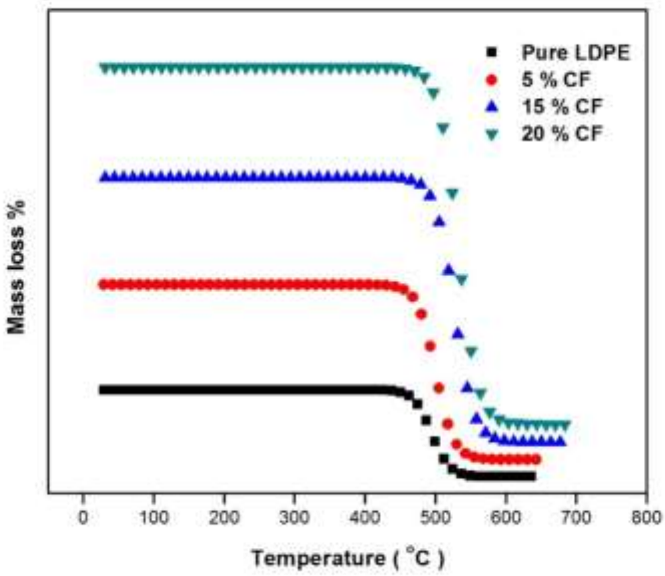
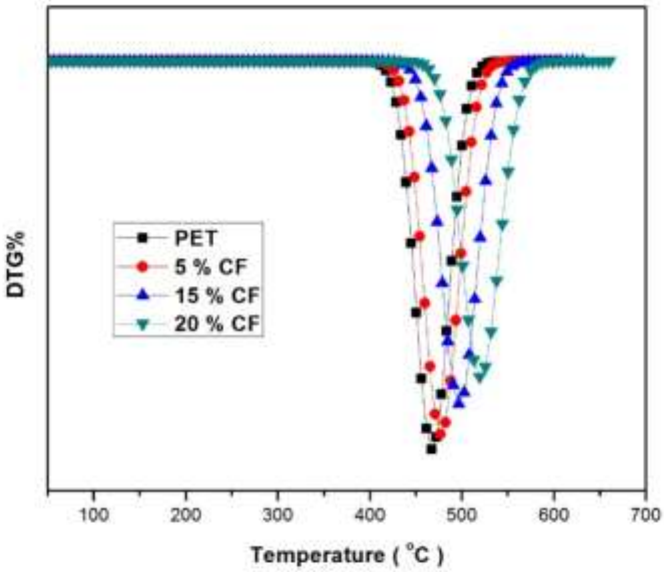


Figure1.TGA curves for pure LDPE and LDPE-CF composites



System%	T_{onset}±0.1 (ºC)	T_{max}±0.1 (ºC)	Residual yield(%)
Pure LDPE	450.5	472.6	17.2
5% CF	475.4	474.5	18.5
15%CF	515.2	499.3	19.4
20%CF	580.2	525.4	20.5

Mechanical analysis of composites

The tests of tensilestress-strain curves in figure 3have evaluatedand analyzedthe effects of adding CF fillers into LDPE. The tensile strength and modulus of elasticity of LDPE-CF composites were increased with the incorporation of CF contents of 5-20.It is evident from figure3and 4that tensile strength increased with adding further amounts of CF fillers (5-20%) to pure LDPE, compared with pure LDPE. From Figure 4, it can be seen that the higher content 20%CF increased to 57.5 MPa by comparing with pure LDPE42.5 MPa. The results of the modulus of elasticity areshown in Figure 5 and that displayed risingin the modulus of elasticity 450.6, 573.39, 702.82MPa respectively when the weight ratios of CF were increased while the modulus of elasticity of pure LDPE was 242.6MPa. The results of elongation at break in Figure 6exhibited a higher value of elongation at break 15.22%, of pure LDPE, compared with 20%CF 9.5%.

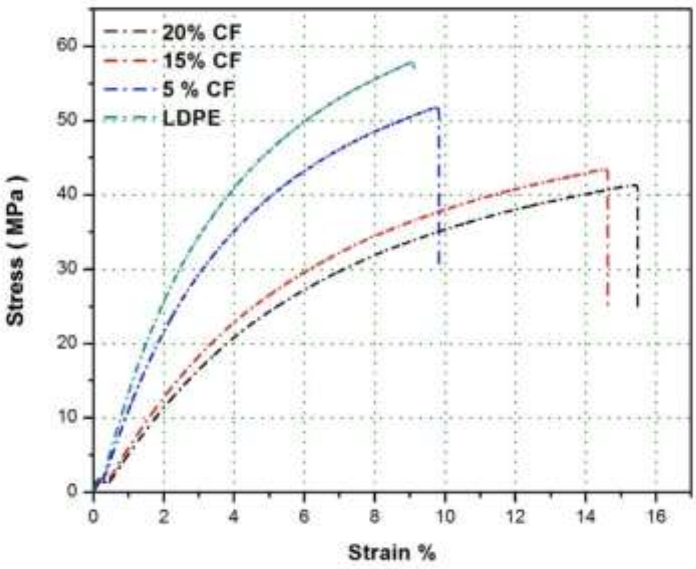


Figure3. Stress-strain curves of pure LDPE and CF-LDPE composites

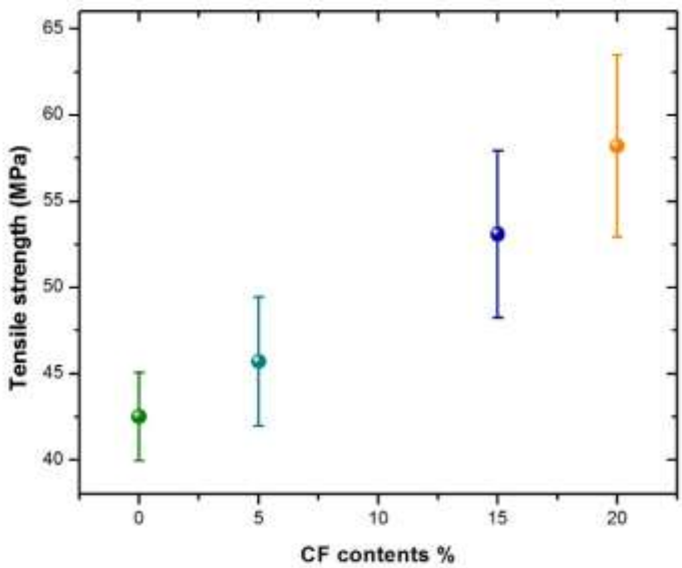


Figure4. Tensile strength versus the contents of LDPE-CF composites

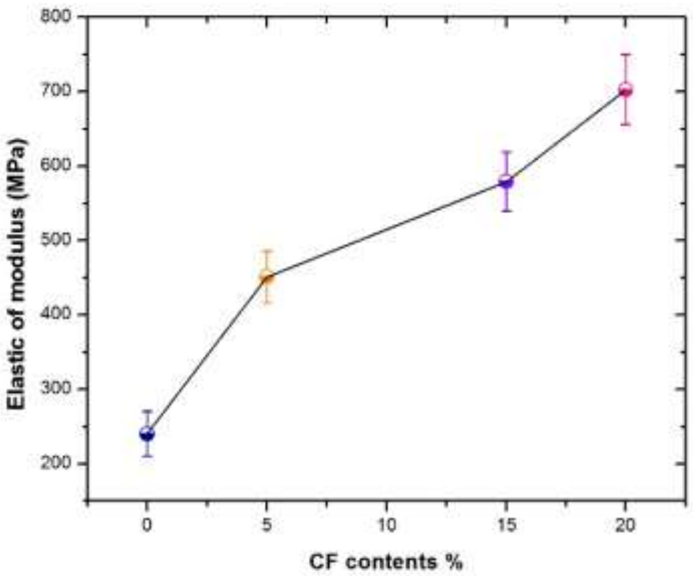


Figure5. Elastic of modulus values versus of LDPE-CF composite contents

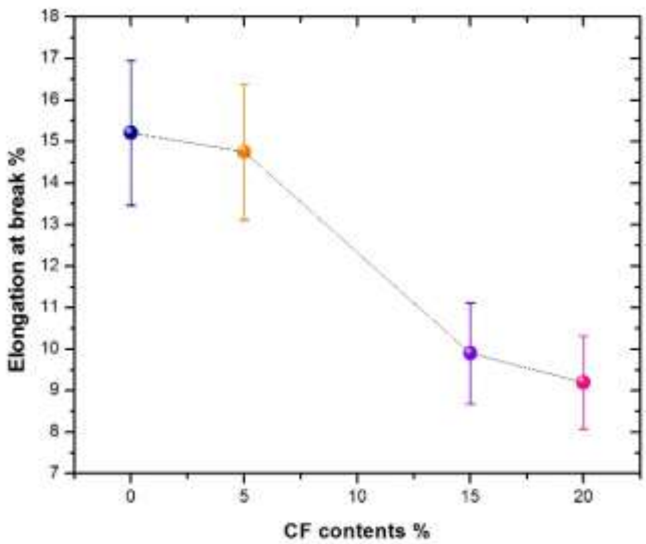


Figure 6. Elongation at break(%) values versus of LDPE-CF composite contents

Conclusion

The additions of CF fillers to LDPE have achieved improvements in the mechanical properties. The tensile strength, the modulus of (LDPE/CF) composite slightly increased with the incorporation of the filler 5-20%. Elongation at break decreased slightly with increasing CF contents. The higher values of CF in pure LDPE enhanced higher thermal stability by comparing with pure LDPE.

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