Thermal and thermo-oxidative degradation of High density polyethylene/Fullerene nanocomposites

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Background: In 1991, Krusic *et al.* revealed the characteristic of fullerene (C_{60}) as efficient free radical scavenger. This suggests the possible use of C_{60} as an effective radical terminator in chain reactions. The degradation of most polymers is through a free radicals chain reaction; in other words, free radicals are the primary cause of polymers degradation. It has been reported that C_{60} could remarkably retard the thermal degradation of polypropylene (PP). The degradation of high density polyethylene (HDPE) is through a free radical chain reaction just as PP. However, much less side chains are found in HDPE than in PP. Therefore, the cross-linking reaction during thermal and thermo-oxidative degradation for HDPE could not been ignored. The mechanisms of thermal and thermo-oxidative degradation for HDPE/C_{60} nanocomposites are believed to differ from that of PP/C_{60} nanocomposites and need to be investigated in details.

Preparation: HDPE/C_{60} nanocomposites were prepared via melt compounding. Nanocomposites containing 0.05, 0.1, 0.25, 0.5 and 2.5 wt% of C_{60} were designated as C_{60}-0.05, C_{60}-0.1, C_{60}-0.25, C_{60}-0.5 and C_{60}-2.5, respectively.

Thermal and thermo-oxidative degradation for HDPE/C_{60} nanocomposites:

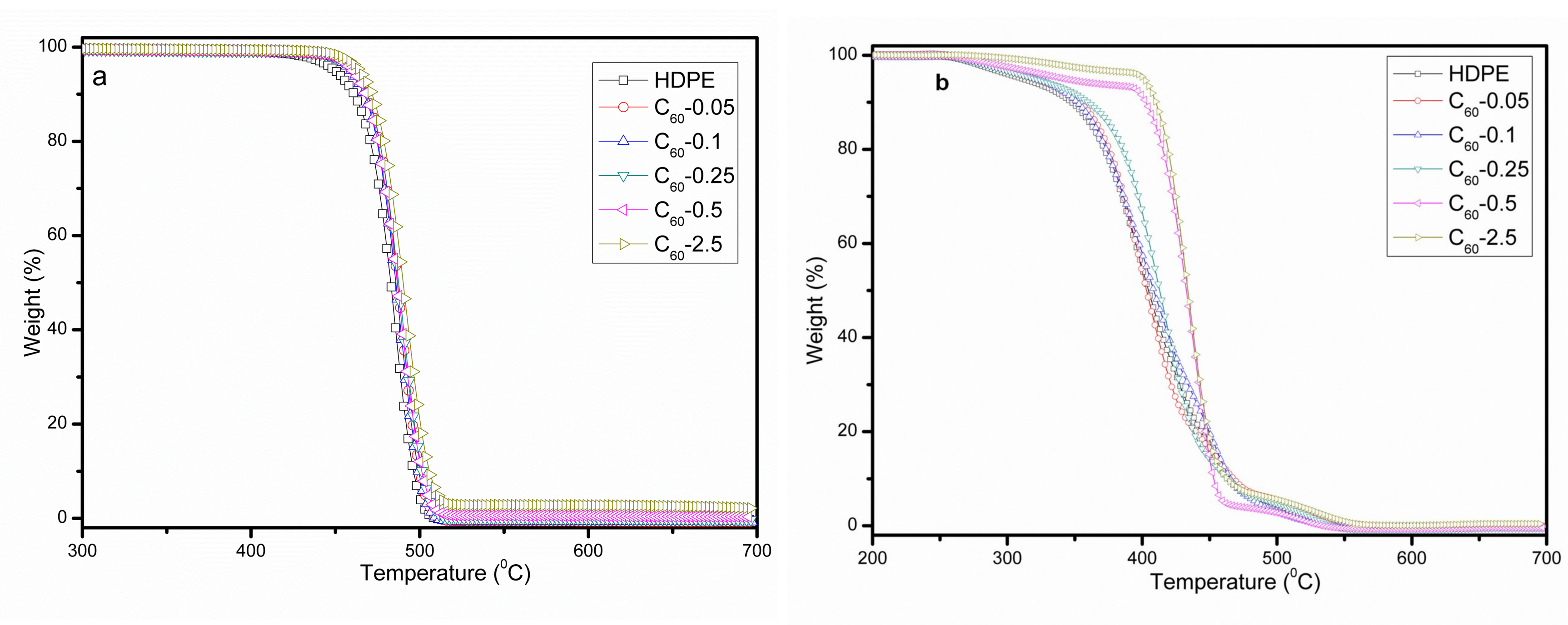

Fig. 1 TG curves for pure HDPE and HDPE/C_{60} nanocomposites in N_2 (a) and air (b)

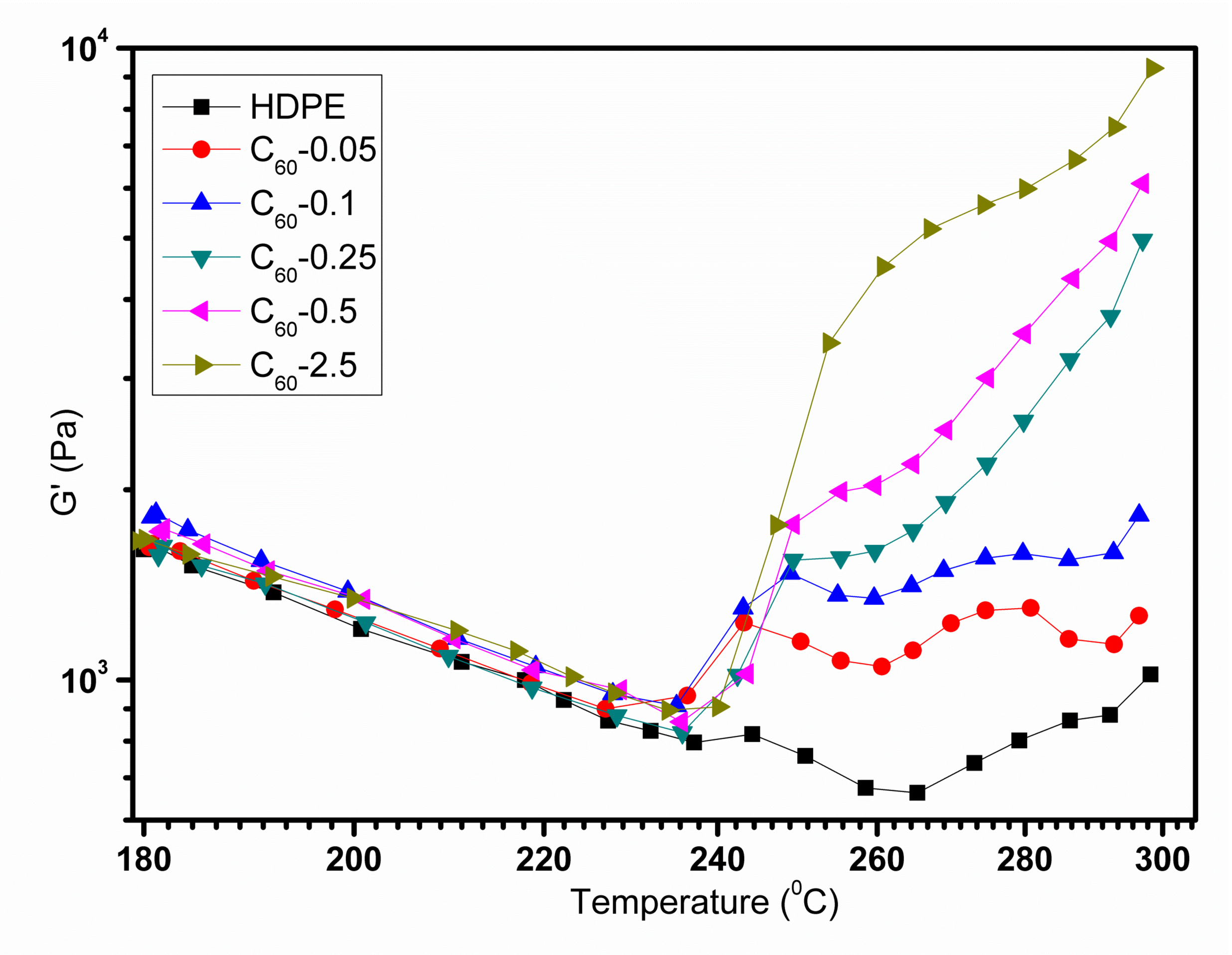

Fig. 2 Dependence of storage moduli (G') on temperature for HDPE and HDPE/C_{60} nanocomposites.

Mechanisms of Thermal and thermo-oxidative degradation for HDPE/C_{60} nanocomposites:

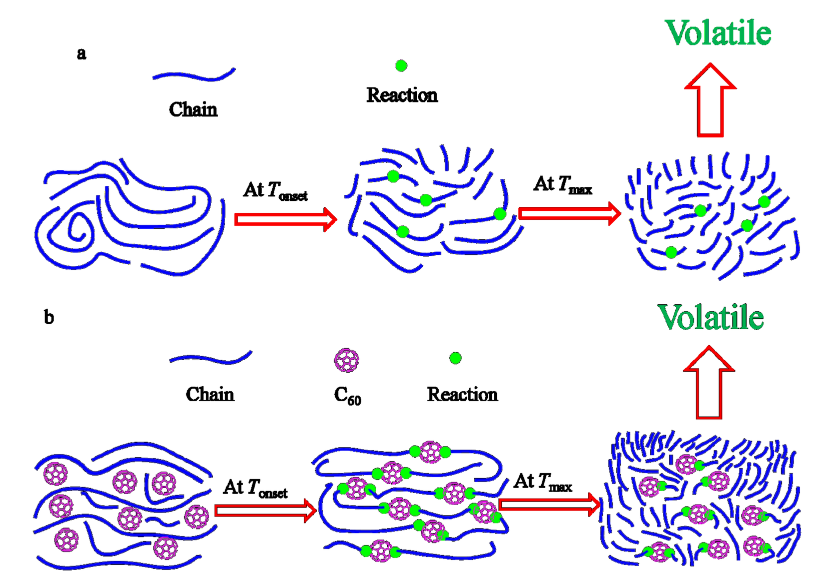

Fig. 3 Schematic representation of the mechanism for the thermal degradation of HDPE/C_{60} nanocomposites in N_2: (a) the thermal degradation process of HDPE; (b) the thermal degradation process of HDPE/C_{60} nanocomposites.

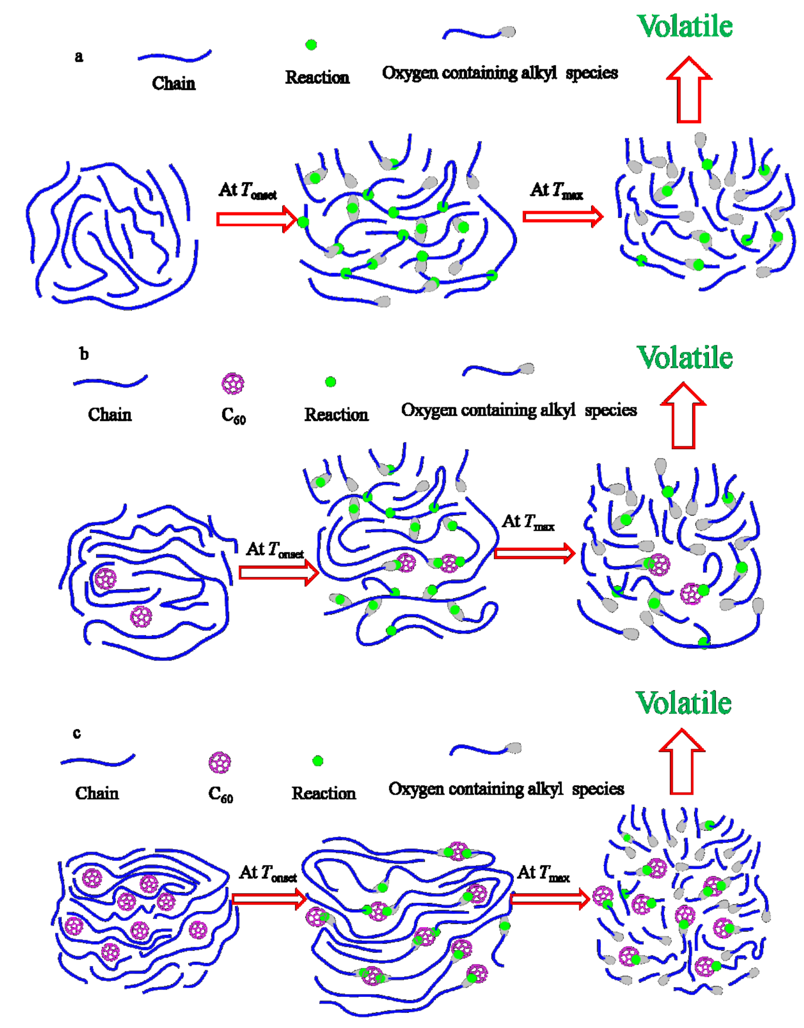

Fig. 4 Schematic representation of the mechanism for the thermal degradation of HDPE/C_{60} nanocomposites in air: (a) the thermo-oxidative degradation process of HDPE; (b) the thermo-oxidative degradation process of HDPE with low concentration of C_{60}; (c) the thermo-oxidative degradation process of HDPE with low concentration of C_{60}.

Conclusions: The presence of C_{60} improves the thermal stability of HDPE in N_2 by trapping carbon centered radicals and it is quite independent of concentration. In air, the thermal stability of HDPE is remarkably improved, especially at high C_{60} content. With high C_{60} concentration, it traps alkyl peroxide radicals and alkyl radicals to inhibit the hydrogen abstraction to suppress the chain scission, which plays a dominate role in the thermal oxidative degradation and changing the degradation of HDPE.

References

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[2] Zanetti M, Bracco P, Costa L. Thermal degradation behavior of PE/clay nanocomposites. Polym Degrad Stab 2004;85:657-665.

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