Thermal Decomposition of Nanodiamond-Filled Polytetrafluoroehtylene: Evidence of Filler-Matrix Chemical Interaction?

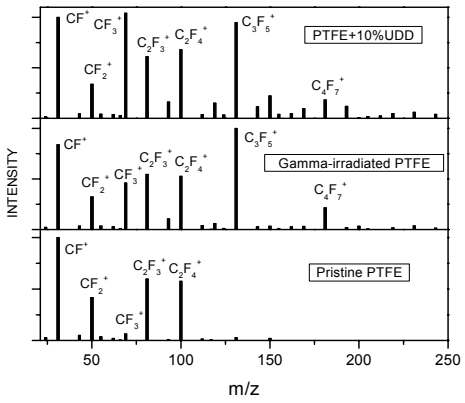
Koscheev A.P., Gorokhov P.V., Perov A.A., Khatipov S.A.

Karpov Institute of Physical Chemistry, 105064 Moscow, Russia

Ultradispersed detonation diamonds (UDD) additives is known to improve the tribo-mechanical properties of polymers [1]. The key question – does nanodiamond filler act as "mechanical" impurity in polymer matrix or there is a chemical bonding formed in the course of composite preparation? We have studied the effect of nanodiamond filler on the chemical composition of gas volatiles released during thermal degradation of PTFE in vacuum.

PTFE composites loaded with UDD (0.03-10 wt.%) were prepared by mechanical milling and thermal pressing. Thermal decomposition of polymer samples during programmed heating (5ºC/min) up to 700ºC in vacuum has been monitored by mass spectrometry. Copolymer FEP-Teflon and γ-irradiated PTFE were used as the model fluoropolymers with chemically modified chain structure (side branches, double bonds) [2] for comparision with UDD/PTFE composite.

The main product of pristine PTFE pyrolysis is the monomer C_2F_4 (m/z=31, 50, 81, 100) in the range 420-600ºC (peak temperature – 590ºC). An additional gas release was observed from UDD/PTFE composite at 550ºC. This peak 550ºC was dominant at high UDD concentrations (10%). The mass spectra of volatiles released from UDD/PTFE indicate the presence of "heavy" ion fragments C_3F_5, C_3F_6, C_4F_7 etc. in contrast to pristine PTFE (see. Figure where all shown spectra were measured near 450-470ºC).



An additional "low temperature" gas release was observed from copolymer FEP (near 500ºC) and γ-modified PTFE (near 450ºC) as well. And again, as in the case of UDD/PTFE composite, mass spectra indicate the desorption of high molecular fragments absent in pristine PTFE. Notice that both UDD/PTFE and γ-PTFE samples exhibit increased wear resistance compared to pristine PTFE (though it was much higher in the case of γ-PTFE).

The observed similarity between volatile compositions in the cases of UDD/PTFE and γ-PTFE allows suggesting the chemical interaction of UDD particles and polymer chains and possible formation of side branches, crosslinking etc. in UDD/PTFE nanocomposite. This type of interaction could be stimulated by mechano-chemical processes during composite mixing.

[1] V.Yu. Dolmatov. *J. Superhard Mater*. **29**, 199 (2007).
[2] A.P. Koscheev et al. *Russ. J. Phys. Chem.* (2008) *(in press)*.