Microscopy of Nanoobjects

Formation of C_4, C_5, and C_9 clusters on carbon material surface and their thermo-desorption removal

I.F. Myronyuk, V.I. Mandzyuk, V.M. Sachko

Vasyl Stefanyk Precarpathian National University, Shevchenko Str., 57, Ivano-Frankivsk, 76018, Ukraine.
E-mail: mandzyuk_vova@ukr.net

The paper studied the process of carbon materials (CM) obtaining by thermolysis of glucose, sucrose, and lactose at 230-355°C and their restructuring when heated to 1000°C in inert and oxidative atmosphere. Weight of carbon materials formed was about 40% in relation to the mass of initial precursor after carbonating process. Further heating of CM in argon atmosphere to 1000°C leads to weight reduction of materials.

Investigation of degradation processes by temperature-programmed desorption mass spectrometry show that weight reduction of materials is due to the formation of volatile carbon clusters with a mass of 66, 93, and 110 u. The largest number of clusters is recorded at 270-280°C. Among them clusters of 110 u dominate with 8-10 % advantage. Number of formed clusters of 93 u reduced to 43 % and the number of that with 66 and 110 u is 30 and 13% respectively when the temperature increasing to 500°C. Clusters of 93, 66, and 110 u are less in 2.8, 3.0, and 8.3 times respectively at 800°C. However, CM derived from glucose at 350°C with limited access of atmospheric oxygen reduces its sublimation activity on 50-70 %; materials derived from lactose and sucrose lose such activity at all.

The research of morphological state of CM by transmission electron microscopy in the maximum resolution regime (scale images is 5 and 10 nm) found that the texture of materials, derived from glucose and sucrose, is formed from microglobules of 2.4-3.0 nm in size. CM obtained by thermal destruction of lactose has a more expressed microcrystallite structure. The layered structure of microcrystallites is formed from 3-10 graphene sheet of 1.0-3.6 nm in size. The distance between the graphene sheets is 0.34 nm.

Unbalanced structural state of materials, the presence of carbon atoms with idle valences, the presence of hydrogen and oxygen heteroatoms provide favorable conditions for the formation of supramolecular structures $[C_4H_2O]^{2+}$ (66 u), $[C_5HO_2]^{+}$ (93 u), and $[C_9H_2]^{2+}$ (110 u) on their surface. The process is accompanied by a change in the valence state of electrons of carbon atoms, i.e. the transformation of sp^2-state to sp-state. Carbenoid chain structure of clusters involves the formation preferably double bonds between carbon atoms.