



National Student Team Contest (first stage)

Task 5. Porous metal from ionic cluster

Metal clusters are the smallest nano-scale compounds which could be applied as precursors for mesoporous materials and metal nanoparticles. Substance A is an ionic compound with a metal cluster-anion of the general formula $[(C_2H_5)_4N]_3^+[X]^{3-}$ which demonstrates catalytic activity in hydration reactions decreasing the temperatures of processes up to room temperature. The corresponding IR spectrum of the substance A (in acetonitrile) contains the following characteristic modes: 1993s, 1991s, 1837m, 1816sh which belong to ligands in the cluster anion.

Thermal decomposition of 1.000 g of the substance A in H_2/Ar leads to 0.574 g of high-pure metal with mesoporous sponge-like structure. According to the XRD data for the metal product the characteristic coherence length is about 9 ± 1 nm that correlates with 5 ± 1 nm obtained from TEM micrograph statistic analysis. The gas-phase products of decomposition are carbon monoxide, water, and nitrogen in a molar ratio of 34 : 20 : 1.

1. Find the composition of the ionic compound A. **(2 points)**
2. What kind of ligand is presented by the given IR vibration modes? **(1 points)**
3. Propose the structure for the cluster anion. **(4 points)**
4. Propose the synthesis method with the maximum yield of substance A. **(2 points)**
5. Estimate the specific surface area of the metal sponge-like decomposition product. **(1 points)**

Total – 10 points