Catalytic Compositions Based on Copper(II) and Iron(III) Chlorides and Bentonite for Low-Temperature Sulfur Dioxide Oxidation with Air Oxygen

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Sulfur dioxide is one of the most widespread environmental impurities which demands great efforts for its removal from air. The work presents some results of our investigation of chemisorption-catalytic behavior of natural bentonite (N-Bent) based compositions containing copper(II) or iron(III) chloride or both these salts in the process of air purification from sulfur dioxide. Both N-Bent and the compositions were characterized by X-ray phase analysis, FT-IR spectroscopy, DTG-DTA, water vapor ad/desorption, pH-metry and also tested in the reaction with sulfur dioxide contained in the air. Figure shows kinetic curves (1-5) representing the time dependences of a final sulfur dioxide concentration ($C_{SO_2}^f$) in the gas-air mixture (GAM) passing through the fixed bed of each composition under study. N-Bent (1) containing montmorillonite as a dominant phase and minor amounts of iron(III) oxide, silicon oxide (α-quartz), calcite, and kaolinite as impurity phases totally absorbs sulfur dioxide for 10 min. Then the sulfur dioxide final concentration rapidly increases and, in 170 min, becomes equal to the initial sulfur dioxide concentration, $C_{SO_2}^{in}$, in the GAM (150 mg/m^3). The kinetics of the process for CuCl$_2$/N-Bent (2) and FeCl$_3$/N-Bent (3) compositions is similar to that shown by N-Bent, however, the amount of sulfur dioxide absorbed is much higher, probably, due to SO$_2$ chemisorption by the metal ions.

The kinetic curves drastically change their profiles for bimetallic compositions CuCl$_2$-FeCl$_3$/N-Bent (4) and CuCl$_2$-FeCl$_3$-KCl/N-Bent (5): periods of time when SO$_2$ absorption is total are much longer, $C_{SO_2}^f$ increases up to the initial one much slower (4) and the amounts of sulfur dioxide entered into the reaction up to a moment when $C_{SO_2}^f$ became equal to $C_{SO_2}^{in}$ (4) and a moment of experiment termination (5) are much higher than those for monometallic compositions. Analyzing the fact that these SO$_2$ amounts many times exceed the amount calculated taking into account the stoichiometry of SO$_2$ reactions with Cu(II) and Fe(III) and also the fact that the times of protective action for bimetallic compositions are many

Figure. Time dependences of $C_{SO_2}^{in}$ in the course of chemisorption-catalytic oxidation of SO$_2$ by compositions 1-5
$C_{Cu(II)} = 5.9 \times 10^{-5}$, $C_{Fe(III)} = 1.0 \times 10^{-6}$ mol/g; t = 20 °C.
$C_{SO_2}^{in} = 150$ mg/m^3

times longer than the sum of protective times for both monometallic compositions, one can conclude that there is a certain synergism in the action of supported CuCl$_2$ and FeCl$_3$ in the case of their simultaneous presence. The true catalytic process takes place for the bimetallic composition (5) containing additional chloride ions (C = 1.0×10^{-6} mol/g) which are supposed to form a coordination sphere of Cu(II) and/or Fe(III) optimal for ascertainment of a closed catalytic cycle confirmed by the steady-state mode of SO$_2$ oxidation with air oxygen.
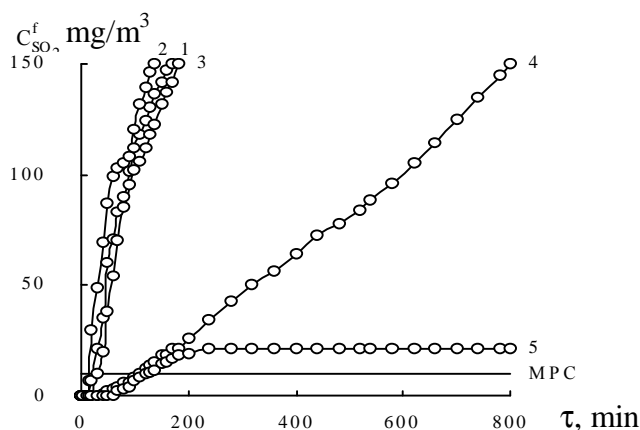
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