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Composition and Catalytic Behaviour of Biogenic Iron Containing Materials Obtained by Leptothrix Bacteria Cultivation in Different Growth Media

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Abstract : The iron containing materials are used as catalysts in different processes. The chemical methods of their synthesis use toxic and expensive chemicals; sophisticated devices; energy consumption processes that raise their cost. Besides, dangerous waste products are formed. At present time such syntheses are out of date and wasteless technologies are indispensable. The bioinspired technologies are consistent with the ecological requirements. Different microorganisms participate in the biomineralization of the iron and some phytochemicals are involved, too. The methods for biogenic production of iron containing materials are clean, simple, nontoxic, realized at ambient temperature and pressure, cheaper. The biogenic iron materials embrace different iron compounds. Due to their origin these substances are nanosized, amorphous or poorly crystalline, porous and have number of useful properties like SPM, high magnetism, low toxicity, biocompatibility, absorption of microwaves, high surface area/volume ratio, active sites on the surface with unusual coordination that distinguish them from the bulk materials. The biogenic iron materials are applied in the heterogeneous catalysis in different roles - precursor, active component, support, immobilizer. The application of biogenic iron oxide materials gives rise to increased catalytic activity in comparison with those of abiotic origin. In our study we investigated the catalytic behavior of biomasses obtained by cultivation of Leptothrix bacteria in three nutrition media – Adler, Fedorov, and Lieske. The biomass composition was studied by Moessbauer spectroscopy and transmission IRS. Catalytic experiments on CO oxidation were carried out using in situ DRIFTS. Our results showed that: i) the used biomasses contain α-FeOOH, γ-FeOOH, γ-Fe2O3 in different ratios; ii) the biomass formed in Adler medium contains γ-FeOOH as main phase. The CO conversion was about 50% as evaluated by decreased integrated band intensity in the gas mixture spectra during the reaction. The main phase in the spent sample is γ-Fe2O3; iii) the biomass formed in Lieske medium contains α-FeOOH. The CO conversion was about 20%. The main phase in the spent sample is α-Fe2O3; iv) the biomass formed in Fedorov medium contains γ-Fe2O3 as main phase. CO conversion in the test reaction was about 19%. The results showed that the catalytic activity up to 200°C resulted predominantly from α-FeOOH and γ-FeOOH. The catalytic activity at temperatures higher than 200°C was due to the formation of γ-Fe2O3. The oxyhydroxides, which are the principal compounds in the biomass, have low catalytic activity in the used reaction; the maghemite has relatively good catalytic activity; the hematite has activity commensurate with that of the oxyhydroxides. Moreover it can be affirmed that catalytic activity is inherent in maghemite, which is obtained by transformation of the biogenic lepidocrocite, i.e. it has biogenic precursor.

Keywords : nanosized biogenic iron compounds, catalytic behavior in reaction of CO oxidation, in situ DRIFTS, Moessbauer spectroscopy
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