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HIGH-VOLTAGE NANOSECOND PULSES AND DIELECTRIC BARRIER DISCHARGE IN AIR CONSEQUENCES ON PHYSICOCHEMICAL PROPERTIES OF NATURAL ILMENITE*

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Ilmenite ($FeO \times TiO_2$ or $FeTiO_3$) and rutile (TiO_2) are the main mineral resources to beneficiation in titanium (TiO_2) content for subsequent hydrometallurgy. Gravity and magnetic separation, flotation are often combined to the separation of ilmenite and rutile from gangues. For ilmenite, there are many pretreatment methods to improve its flotability, such as the surface dissolution, roasting, oxidation, introducing ions, attrition-scrubbing raw ores, and microwave irradiation. In this paper we present the results of experimental studies on the impact of two types of nonequilibrium electrical discharges (high-power electromagnetic pulse (HPEMP) and dielectric barrier discharges (DBD) in air at atmospheric pressure) have on the surface morphology, microhardness, and physicochemical properties of natural ilmenite (Juina deposit of Brazil).

With the HPEMP effect, the duration of high-voltage nanosecond pulses was 4–10 ns. Pulse amplitude U~25–30 kV; strength of the electric field in the 5 mm interelectrode gap, E~10^7 V×m^{-1}; rate of pulse repetition f=100 Hz. Electrode voltage in the cell of the barrier discharge generator, 20 kV; pulse duration, 8 μs; duration of a pulse leading edge, ~300 ns; rate of pulse repetition, 16 kHz; length of interelectrode gap, ~5 mm. The duration of sample treatment varied in the range t_{treat}=10–150 s. Infrared spectra (FTIR) of ilmenite were recorded throughout the region of 4000–400 cm^{-1} (spectral resolution, 4–6 cm^{-1}) using a Nicolet-380 spectrometer equipped with a special Smart Diffuse Reflectance accessory. Morphology, defects, and elementary composition of new micro- and nanoformations on mineral surface of ilmenite particles have been investigated using methods of Scanning Electronic Microscopy, X-ray Spectral Microanalysis (SEM–EDX) and Confocal Laser Scanning Microscopy (CLSM). The mineral's microhardness was determined according to Vickers (*HV*, MPa) using the standard he procedure and a PMT-3M microhardness tester. The load on the indenter was 100 g, and the period of loading was 10–15 s.

Extended fragmented traces of streamer discharges with a complex discrete internal structure formed on the surfaces of ilmenite particles as a result of brief (t_{treat}=10–30 s) nonthermal HPEMP treatments (Fig. 1a). When the duration of electrical pulse treatment was extended, ilmenite microhardness fell monotonically from ~670 MPa in the initial state to ~520 MPa (t_{treat}=150 s). The relative drop in microhardness ΔHV_{max} was ~22.4%. The morphological changes in the mineral surface due to the DBD effect were related to the formation of erosive microcraters and paths (Fig. 1b) that resembled microstructural features of the imprints (autographs) of current channels of high-voltage microsecond spark discharge. The ilmenite's microhardness fell monotonically (from 670 MPa in the initial state to 590 MPa at t_{treat}=150 s, ΔHV_{max} was ~12%). Advantages are shown of using brief energy (HPEMP and DBD) treatments (t_{treat}=10–30 s) to modify the chemical structure of surfaces of ilmenite and its physicochemical properties (contact angle, and electrokinetic potential) in order to improve the efficiency of processing complex titanium ores.

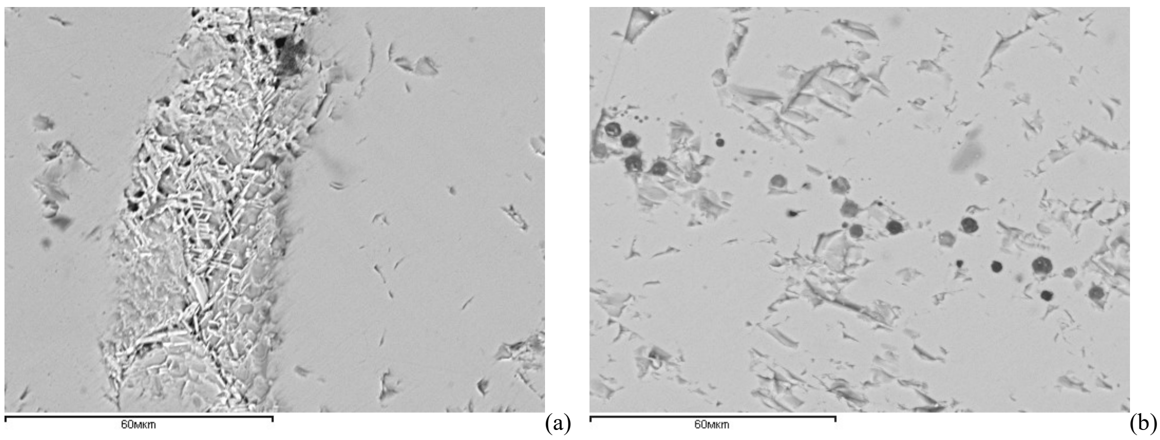

Fig.1. SEM-images of ilmenite surface as a result of (a) HPEMP and (b) DBD treatment (t_{treat}=50 s). SEM; scales 60 μm.

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