

Creation of nanoparticles and surface nanostructures of aluminum oxides by hot water treatment

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Metal oxide nanostructures (MONSTRs) and nanoparticles (MONPs) produced by treatment of the metal surface have unique physical and chemical properties. Recently, MONSTRs have been used in electronic [1], optical [2, 3] and sensitive [2] devices of an evidence-based concept; however, their synthesis methods have several obstacles that limit their large-scale production. Recently, a simple hot water treatment (HWT) process has been used to produce MONSTRs on surface of various metals, their compounds and alloys by a one-step, scalable, low-cost, and eco-friendly technique [4]. But, up to date there are no systematic studies of MONSTRs formation. Here we present the results of investigation the formation of aluminum oxide nanostructures during HWT at different water temperatures and treatment durations. Moreover, we show that this technique can be used for synthesis of water suspension of metal oxide nanoparticles.

It was shown that at the temperatures below 70 °C the nanostructure formation didn't occur. After HWT at higher temperatures the surface of aluminum plate has been covered by nanostructures with uniform spatial distribution. The density of nano-sheet structure monotonously increased with water temperature. Treatment of plate in boiling water leads to appearance of additional cavitation holes in the plate surface.

The investigation of the nanostructures formed after HWT at fixed temperature (85 °C) for different treatment duration from 2 to 30 minutes allowed to reveal the islet growth character. After 4 minutes treatment the nanostructures locally covered sample surface. The covered area increased with treatment time and after 16 minutes the surface was completely covered by aluminum oxide nanostructures. Investigation The mean thickness of nanostructures about 450 nm does not depend on the temperature.

It was shown that aluminum oxide nanostructures lead to significant change on sample surface wettability. The wetting angle of untreated sample surface was 69°. The aluminum surface became superhydrophilic at temperature range from 70 to 95 °C with almost zero wetting angle. The relaxation of this state becomes very slow with temperature increase and remained close to zero for above 400 hours after HWT at 95 °C.

It was shown that HWT leads also to formation of water solution of nanoparticles Al₂O₃ with mostly spherical shape and mean sizes about 30 nm and large dispersion, which didn't depend on the treatment temperature. The obtained results have been attributed to creation of the aluminum oxide molecules in the water during HWT [4]. This effect leads to formation of the microstructures at the metal surface and nanoparticles in the water. The similar results were obtained for laser ablation [5].

The obtained effects can be used for modification of the metal surface wettability and to creation of the water suspension of metal oxide nanoparticles.

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