Microsc Microanal 15 (supp 3), 2009

doi:10.1017/S1431927609990717

Electron-microscopic observation of $BaTiO_3$ prepared by additive assisted aqueous synthesis

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Bulk barium titanate ($BaTiO_3$) has found widespread applications especially in multi-layered ceramic capacitors (MLCCs) and embedded decoupling capacitors (EDC). In the last years, the interest in one-dimensional (1D) nanostructured ferroelectric systems (nanotubes, nanowires, nanorods, nanobelts, nanofibers) is increasing. Recently theoretical studies reported an enhancement of ferroelectricity in 1D systems [1]. Although the hydrothermal and aqueous synthesis of equiaxed barium titanate powders have been thoroughly investigated [2-4] the growth of barium titanate anisotropic nanoparticles still less known. Indeed it is particularly dificult to modify the crystal habit by hydrothermal and related methods. However it is expected that the presence of some additives during the synthesis will change the growth kinetics.

In this work the electron microscopy study of the effect of poly(acrylic acid) (PAA) and hydroxypropylmethylcellulose (HPMC) additives on the anisotropic growth of $BaTiO_3$ by aqueous synthesis is reported.

Figure 1 shows the X-ray diffraction paterns of the samples prepared in the presence of a) PAA and b) HPMC. As can be noticed cubic barium titanate is formed independetly on the used additives or on their concentration. In addition with the increase of the concentration of HPMC more barium carbonate is formed (Fig. 1b). This seems to suggest that HPMC is interacting more with Ti source than PAA.

When the synthesis is performed in the presence of high concentration PAA directed agregation of $BaTiO_3$ particles is observed (Figure 2a). However when the synthesis of barium titanate occurs in the presence of high concentrations HPMC barium titanate particles with different morphologies are formed (Figure 2b).

The SEM X-Ray mapping (Figure 3) confirms that Ti and Ba are homogeneously distributed in the obtained powders.

Incipient dendritic growth was observed under the presence of low concentrations of PAA (Fig. 4a). Although the SAED indicates a crystal growth direction along <001> axis of the cubic structure it is difficult to say that this is the preferential growth direction of the dendritic particles. The directed aggregation observed by SEM and the incipient dendritic growth noticed by TEM analysis indicate that the PAA is probably inducing an anisotropic growth. By analyzing the SAED of the barium titanate particles obtained under low concentration of HPMC (Fig. 4b) the growth habit along <001> direction is also verified.

As a conclusion, SEM and TEM studies proved that the used of such additives markedly affect the crystalization of barium titanate.

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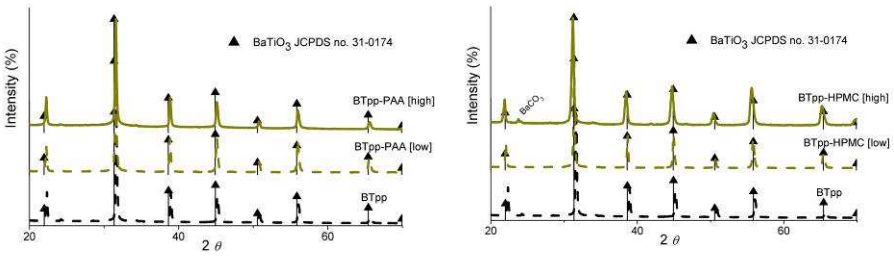

Fig. 1. XRD patterns of BT powders obtained in the presence of *a)*PAA; *b)* HPMC

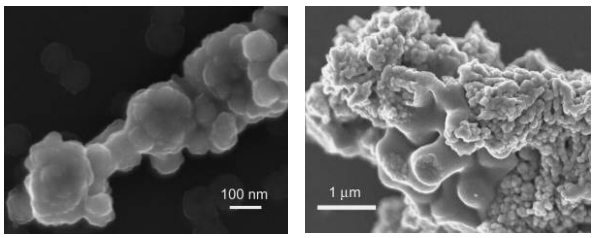

Fig. 2. SEM of BT powders obtained under high concentration of *a)* PAA; *b)* HPMC

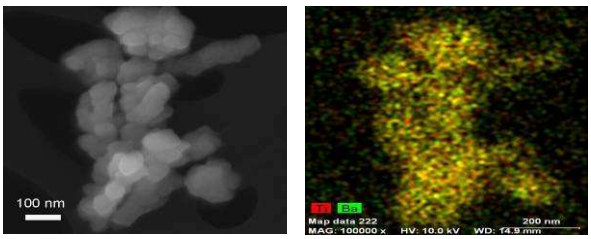

Fig. 3. SEM X-Ray mapping of the BT powders obtained under high concentration of HPMC

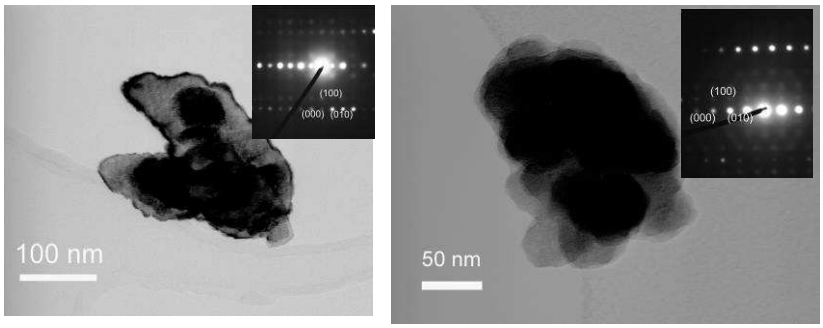

Fig. 4. TEM (inset EDP) of BT powders obtained at low concentration of *a)*PAA; *b)* HPMC

https://doi.org/10.1017/S1431927609990717 Published online by Cambridge University Press