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Containerless Synthesis of Ceramic Materials Using Microwave Heating

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Recently, it has been demonstrated that microwave heating techniques may be employed for the synthesis of a number of multicomponent ceramic oxide - based materials, e.g. $YBa_2Cu_3O_7$ and $CuFe_2O_4$. A characteristic, and potential extremely useful, feature of such syntheses is that they occur in significantly less time than that required using conventional furnace - based techniques. However, the information obtained to date is necessarily rather empirical, and systematic investigations of the use of microwave heating for the syntheses of ceramic materials are required.

The syntheses of ceramic materials at high temperatures are often affected by unwanted, deleterious reactions of the reactants and/or products with the reaction container. This may severely limit the choice of available container materials.

Consequently, it is of interest to investigate the high temperature synthesis of ceramic materials using microwave heating in a containerless environment. Suitable candidate materials for initial study include, for example, the ultra - hard borides and carbides.

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Preparation of pure oxide - based phases using microwave heating

Product	Starting Materials	Microwave Heating Time*	Conventional Heating Time**
La_2CuO_4	La_2O_3, CuO	10 - 30 min	12 - 24 hr
$CuFe_2O_4$	Fe_2O_3, CuO	30 min	23 hr
$BaWO_4$	BaO, WO_3	30 min	2 hr
KVO_3	K_2CO_3, V_2O_5	7 min	12 hr

* For a power level of 500 W.
** Refers to use of resistive (i.e. furnace - based) heating.

D. R. Baghurst and D. M. P. Mingos, J. Chem. Soc., Chem. Comm. 829 (1988).

D. R. Baghurst, A. M. Chippindale and D. M. P. Mingos, Nature 332, 311 (1988).

Processing of Ceramics in a Microgravitational Environment

1) Sedimentation

- Powder processing
- Particle-size distribution effect on further processing
- Compare with solution-based methods

2) Particle shape

- Ideally spherical particles
- Better powder packing leading to

  shorter solid-state reaction times (surface area/energy effects)

  lack of exaggerated grain growth (increased strength)

3) Containerless Processing

- Impurity control

Other applications:

- Annealing phenomena

  local temperature distribution

- Phase transitions