Journal of the European Ceramic Society **15** (1995) 469–477
Elsevier Science Limited
Printed in Great Britain.
0955-2219/95/$9.50

0955-2219(95)00009-7

Compaction and Sintering Behaviour of Sol–Gel Powders

Y. Jorand,[a] M. Taha,[a] J. M. Missiaen,[b,d] & L. Montanaro[c]

[a]G.E.M.P.P.M., U.R.A. C.N.R.S. 341, I.N.S.A. Lyon, Bat. 502, 69621 Villeurbanne Cedex, France
[b]C.P.P.I., E.N.S. des Mines de Saint-Etienne, 158 cours Fauriel, 42100 Saint-Etienne, France
[c]Department Materials Science & Chemical Engineering, Politecnico, Corso Duca degli Abruzzi 24, 10129 Torino, Italy.
(Received 4 December 1992; revised version received 11 September 1994; accepted 12 December 1994)

Abstract

Dry pressing is the most common industrial shaping process for ceramic pieces. Sol–gel powders are of high reactivity, but very often agglomeration–aggregation phenomena limit this advantage by inducing poor compaction behaviour. Consequently the goal of sol–gel powder research — to obtain full densification at very low sintering temperature, is not achieved. With the intention of showing the influence of sol–gel powders, specific characteristics on pressing, compaction diagrams and green body characteristics of two experimental zirconia sol–gel powders have been determined. For comparison a well-known commercial product was used as a control. These observations were correlated as densification tests and initial powder characteristics. The sol–gel powder parameters that must be adapted to dry pressing forming and the incidence of the synthesis conditions, have emerged.

1 Introduction

Dry pressing is a method extensively used for the industrial production of ceramics. It is well known that the quality of ceramic bodies is strongly influenced by the characteristics of the starting powder. A powder having good compaction behaviour gives a high-density green compact and, more importantly, a fine and homogenous porosity. This results in a high-density sintered body as already shown in many studies.[1]

The major source of the defects observed in a green body originates in the characteristics of the different constituents of the powder. The different constituents of a powder can be defined in different ways, so we will explain the definitions used in this text. The smallest unit of a powder which can be considered is the crystallite. It can be defined as a coherently diffracting region, and measured by X-ray diffraction line broadening. In a first approximation, the potential reactivity of a powder can be linked to the crystallite size (in fact a crystal can be constituted of several crystallites): this is not far away from the minimal particle size that can be individualised. In classical powder processing these particles do not appear alone, but clustered into either the aggregates or the agglomerates, depending upon the nature of the binding forces. An aggregate is an arrangement of crystallites held together by strong binding forces, e.g. chemical bands in solid bridges. A typical example is the aggregates formed during calcination of Bayer aluminas. Consequently, aggregates retain their identity under a wide variety of severe conditions, and especially under high compaction pressure.[2] The agglomerates are constituted of crystallites and/or aggregates held by weak binding forces, such as Van der Walls or electrostatic forces. Agglomerates, in contrast to aggregates, are much more easily disrupted by external forces.

All fine particle size ceramic powders contain agglomerates, because Van der Walls forces exceed gravitational ones, and very often, depending on the synthesis process, aggregates. When the powder is poured into a compaction die, one can distinguish three porosity types: interagglomerate, interaggregate and intraaggregate porosities. Irregularly shaped particles (agglomerates and/or aggregates) affect the flowability of the powder, and lead to the creation of gross interagglomerates/interaggregate porosities by promotion of arch formations. If agglomerates, or more frequently aggregates, are resistant to compaction forces, this induces packing inhomogeneities in the green

[d]Now at: Laboratoire de Thermodynamique et Physico-Chimie Métallurgiques, E.N.S.E.E.G., B.P. 75, 38402 St Martin D'Hêre Cedex, France.