Some Effects of Aggregates and Agglomerates in the Fabrication of Fine Grained Ceramics

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INTRODUCTION

The processing engineer in production tends to equate processing with productivity. But viewed as a science, powder processing can be defined as the sequence of operations which systematically enhances the particulate character (presintering operations) and ultimately the composition and structure of the product material (sintering and surface finishing). Processing is a systems problem. Many functional operations and parameters are involved. But the continuous thread is the evolution of the chemical and physical character.

One very common cause of microstructural inhomogeneities (usually defects) is the inadequate control of aggregates* and agglomerates* in powders. Typical aggregates are crystallites held together by diffusion bonds. Agglomerates are more variable; the bonding forces may be surface charges, hydrogen bonds, van der Waals bonds associated with adsorbed organic molecules, and magnetic forces in ferrimagnetic powders. If moderate cementitious bonds exists, the distinction is less clear. Agglomerates are normally porous. Aggregates can be completely dense or porous.

*Here a group of particles held together by strong and weak forces are termed aggregates and agglomerates, respectively.
Although the recognition of agglomerates and aggregates has increased in the past few years, research studies of their structure and their origin, persistence, and ultimate effects are rather sparse.\textsuperscript{1-6} This paper discusses some effects of aggregates and agglomerates in the processing of technical ceramics.

**Solid State Reactions**

Calcined powders typically contain aggregates and a significant percent of these can escape/resist fracture on milling and/or high speed blunging. In studies of the mixing of suspensions of aggregated zinc oxide and unaggregated alumina, the size of the aggregates was $<6 \, \mu m$ using a high speed impeller but sizes ranged up to $12 \, \mu m$ on using a low speed impeller. Ultimate crystallites were much finer but aggregates were $\geq$ size of the particles of alumina. On heating compacted mixtures at $1200^\circ C$, retarded reaction after 30 min. and incomplete reaction after 210 min. was traced to the presence of the coarse aggregates. This can be expected because the maximal diffusion path is a function of the size of the aggregates rather than the ultimate crystallites.

![Histogram for commercial, milled barium titanate powder](image-url)