EC DENTAL SCIENCE
Short Communication

Dental Ceramics: New Emerging Techniques for their Sintering

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Ceramics have been an important part of human culture. The art of ceramics is one of the oldest known, dating to prehistoric times and have played a key role in innumerable human endeavors. The term ceramic refers to any product made essentially from a nonmetallic inorganic material. In Dental science, ceramics are referred to as nonmetallic, inorganic structures primarily containing compounds of oxygen with one or more metallic or semi-metallic elements usually processed by firing (sintering) at a high temperature to achieve desirable properties. Sintering is a densification and agglomeration process of physically packed particles to form the desired shapes at relatively high temperatures but without melting. It involves elimination of the initial porosity to obtain a denser product. Calcination refers to thermal treatment which removes volatile fraction. Calcination treatment prior to sintering improves the densification of ceramics e.g. in the case of hydroxyapatite, a bioceramic, calcining at 900°C prior to sintering at 1250°C results in a higher bending strength (about 55MPa) with finer grain size.

Sintering of dental ceramics includes emerging new techniques on sintering which include:

1. Spark plasma sintering (SPS) is a form of sintering where both external pressure and an electric field are applied simultaneously to enhance the densification of the amorphous or metallic/ceramic powder compacts. This form of densification uses lower temperatures and shorter amount of time than typical sintering. The theory behind it is that there is a high-temperature or high-energy plasma that is generated between the gaps of the powder materials; materials can be metals, inter-metallic, ceramics, composites and polymers. It is a novel technique used to sinter ceramics, metals and composites within a few minutes and to obtain densities greater than 99.9%.

2. Selective laser sintering (SLS) is an additive manufacturing technique that uses a high power laser (for example, a carbon dioxide laser) to fuse small particles of plastic, metal (direct metal laser sintering), ceramic, or glass powders into a mass that has a desired 3-dimensional shape.

3. A microwave furnace can sinter dental ceramics within 1/12th the time of a conventional oven. Microwave has the added advantage of producing better mechanical strength and resistance to low temperature degradation. In order to be effective, the ceramic powders to be sintered are to be surrounded by microwave susceptors such as ferric oxide. Microwave is the best choice for sintering dental ceramics such as Zirconia. Dental laboratories, overloaded with requests, usually take seven or more days to process the permanent dental restoration with a conventional oven.

4. In magnetic pulsed compaction (MPC), it is possible to apply a high pressure (up to 5 Gpa) to a ceramic powder for a short period of time (~ 500 μs) which results in improved density.

5. Vacuum sintering. ZrO_2 based ceramic materials have unique properties (high abrasion resistance, strength and breakdown viscosity), and are being used in different technologies. A basic characteristic of the fabrication of such materials is that during traditional sintering at 1600°C in air to obtain high densities causes a Tetragonal to Monoclinic transformation on cooling, which destroys the sample, due to grain enlargement. However, sintering at vary low partial oxygen pressure (10^{-6} Pa) stabilizes the high temperature tetragonal phases of ZrO_2 similar to oxide additives (CaO, MgO, Y_2O_3, etc).

It is quite usual in dentistry to adopt a material and/or technique from engineers and adapt it to clinical conditions. A good example of such an instance is dental ceramics and their manufacturing. This opens a wide range for research to evaluate these techniques especially if we know that they offer many advantages like energy conservation and time saving when compared with the conventional techniques.

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