Down to the bone

Use of Laboratory Grinders for Size Reduction of Human Bones and Bioceramics

Bone implants and substances for bone regeneration are used in surgery to replace degenerated bone material by implants or to "re-build" it with specific substances. The material used in implants varies from autogeneic (supplied by the patient) through allogeneic (supplied by a donor) bones to replacement materials such as hydroxylapatite (HA) and tricalcium phosphate (TCP). Bovine bones and corals are used in conjunction with synthetically produced foamed materials to form a basis for the regeneration of bone substance. Various Retsch mills are suitable for the preliminary and fine grinding of human bones as well as bioceramic materials.

Fig. 1: Retsch Planetary Ball Mills are used for fine size reduction down to the submicron range.

Bioceramics are non-metallic inorganic materials which are used as components of prostheses and implants in medical engineering. The surfaces of bioceramic materials have a favorable sliding friction behavior in combination with a very low degree of material abrasion. These properties make them especially suitable for orthopedic applications. Aluminum oxide and zirconium oxide ceramics, for example, are used for coating the articulation surfaces of artificial limbs. Hydroxylapatite is the main mineral component of living bone and can also be manufactured synthetically as a ceramic material. It is used for both implants and prostheses as well as for crowns and bridges in the dental sector. Further advantages of bioceramics are excellent biocompatibility and very high abrasion resistance.

Suitable Mills and Grinding Tools for Bioceramics

The first requirements for preparing and processing bones and bioceramics are hygiene and cleanliness. Therefore, when selecting a suitable laboratory mill, easy cleaning of the grinding tools and all parts that come into contact with the material are essential. It is also important that cross-contamination by abrasion is avoided and that the grinding tools can be sterilized. Given these preconditions, ceramic grinding tools are the best choice for pulverization, in particular yttrium-stabilized zirconium oxide (YSZ) with its high degree of resistance to abrasion. If metallic grinding tools are used then abrasion is to be expected which could interfere with the following processing steps.

The jaw crusher BB 51 is suitable for the preliminary size reduction of hard-brittle products.

Fig. 2: The Cutting Mill SM 300 is suitable for preliminary size reduction of bone material.

Fig. 3: Degreased human bones before and after grinding in a cutting mill

The crushing chamber of this compact benchtop instrument is lined completely with zirconium oxide and sealed dust-tight, so that possible contamination of the material during size reduction can be eliminated. Disk mills such as the DM 200, which have grinding disks made from high-quality zirconium oxide, are also suitable for this application.

Fine or ultrafine pulverization to the required particle sizes of 100 microns and down to the nanometer range is then carried out in a Planetary Ball Mill. Grinding jars made from six different materials, including zirconium oxide, are available for the PM 100, PM 200 and PM 400; the jar volumes range from 12 to 500 ml. In order to achieve the desired degree of fineness and to minimize abrasion it is important to select the correct jar filling. In most cases the following rule of thumb can be used to achieve reliable results: one third sample, one third grinding balls. This leaves enough space for the movements of the mixture of material and grinding balls. Both the grinding jars and the grinding balls can be autoclaved and can therefore be used for sterile operation.

For the preparation of bone substance it is frequently necessary to obtain individual fractions from the basic material that cover a defined particle size range. Sieve shakers such as the AS 200 control for sieves up to 203 mm diameter are used for this or, if larger amounts need to be sieved, the AS 300 control for sieves up to 305 mm diameter. The sieving parameters can be set digitally on both instruments, which guarantees reliable and reproducible results.

Processing Human Bone

Beside synthetic bone substitutes human cortical bone is used for bone grafts and implants. Tissue banks which collect and process donor organs, supply bone powder as sterile substances in various fractions which are then made available for surgical purposes.

The "South Texas Blood and Tissue Center" (STBTC), which is located in San Antonio, Texas, uses Retsch instruments for preparing bone powder from human bone material. Here the preparation of the degreased, dried and sterilized bones, which have been sawed up into approx. 3 x 3 cm pieces, initially takes place in a cutting mill with a 4 mm sieve in which the bone material undergoes preliminary size reduction to the desired fraction of 250 µm to 850 µm. Tissue Quality Manager Ray Adams uses the aluminum plunger for the cutting mill as this is easier to sterilize than the standard wooden plunger. After the first grinding step, STBTC uses the Sieve Shaker AS 200 control for classification of the bone powder. The analytical test sieves guarantee contamination-free sieving, as they contain no foreign materials such as solder or epoxy.

To maximize the harvest in the fraction 250 µm to 850 µm, the oversize from the 850 µm sieve is submitted to the ultra centrifugal mill ZM 200 for pulverization. This rotor mill allows to determine the grind size by using ring sieves with different aperture sizes. The grinding tools as well as all other parts coming into contact with the sample material can be removed without effort and sterilized. The overall processing time is no more than 30 minutes which helped the STBTC to considerably increase the throughput of donor samples. William Bordano, Director Tissue Services at the STBTC is not only more than content with the increased efficiency, he also stresses that the quality of the bone powder has resulted in increased yields and commends the safety features of the mills.

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