Particle size impacts battery electrode and battery performance

In recent years Nano materials whose physical and chemical properties are quite different from bulk material, are expected to play a key role in the performance improvement of rechargeable Li-ion battery technology. Nano materials increase the surface area, leading to higher electrode–electrolyte contact and thus enhance the reaction rate. Ball milling is a perfect top down approach and a method which will suit to reduce size of particle to fine-tne the grain sizes of the materials to required levels. Commercial synthetic Zeolite powder with particle size larger than 45 μm can be reduced into the size range between 0.2 to 0.3 μm by planetary ball mill [1].

The variables which normally researchers consistently use for study and use it to optimize for getting the size of the powder particle of their choice are : factors such as Milling speed, Size of balls used and Ball to powder weight ratio.

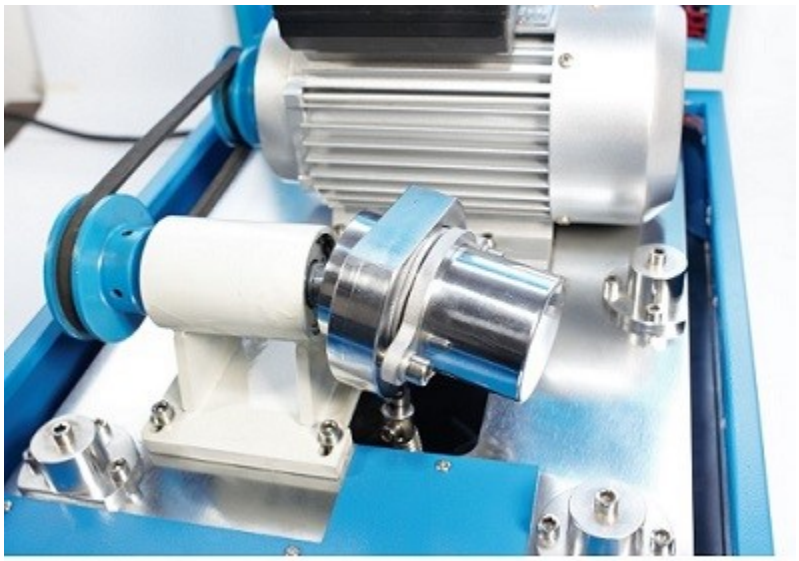
Studies [2] of ball milling of Commercial LiFePO4/C powder with 10% carbon content, carried out at a speed of 400 rpm with a ball-to powder ratio of 10:1 for different durations of 5 (LFP-5), 10 (LFP-10), 15 (LFP-15) and 20 hours (LFP-20) it is proven to help obtain particles of Nano size .The effect of particle size reduction on conductivity, activation energy and diffusion coefficient of LiFePO4/C has given promising results in the studies to the researchers. By fabricating CR2032 cells, they found that the conductivity and diffusion coefficient increased by an order of magnitude,

and activation energy is reduced by half by reducing the particle size from micro level to nano level. Cathode material in micron size is ball milled for different durations to reduce the particle size to nano level in these studies.

Mechanical milling allows even the preparation of alloys and composites, which cannot be synthesized via conventional routes. The energy transfer to the powder particles in these mills takes place by a shearing action or impact of the high velocity balls with the powder. Wet milling is also a common method used and in wet milling both the speed of rotation and the milling time will affect the result. When the mill is rotated with an appropriate speed, the balls will be lifted by friction against the cylinder wall and fall towards the bottom of the cylinder, crushing the WC grains against other milling balls or the cylinder wall. Smaller balls and/or higher rotation speed of the mill, will give abrasion and chipping as opposed to crushing of the particles. The milling efficiency decreases with increased milling time as the particles

With the starting material as α-alumina powder [3], starting crystal size of 86nm., it was milled at different time ranges from 0 to 60 minutes and milling speed ranges from 400 rpm to 1100 rpm using a wet milling technique in corundum abrasive materials. The wet milling technique involved the use of water with the alumina to water ratio of 1:6.1. Results from these analysis showed that the crystallite size will get smaller when milling speed and time of more than 600rpm and 30 minutes respectively were used. Optimum conditions to achieve the smallest crystal size of 79.7nm are 1000 rpm and 60 minutes.

In yet another work [4], they reviewed the findings of some of the researchers, relevant to the ball milling process for soft magnetic materials such iron, cobalt and nickel and to emphasize the importance of key process parameters on grain size, particle size and performance characteristics.



The inferences made in the above studies with wider literature reviews are:

a) Ball milling processing parameters (ball to powder ratio, size of the balls, material of the balls, jar size, milling time, milling speed) have a strong influence on the particles size of brittle materials which undergo particle size reduction, and in the case of ductile materials there is a reduction in crystallite size due to sever plastic deformation as a result of high energy impact.

b) There is a need for a mathematical model, which relates processing parameters to particle size or grain size for a given material would be of great help for getting accurate characteristics.

References:

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