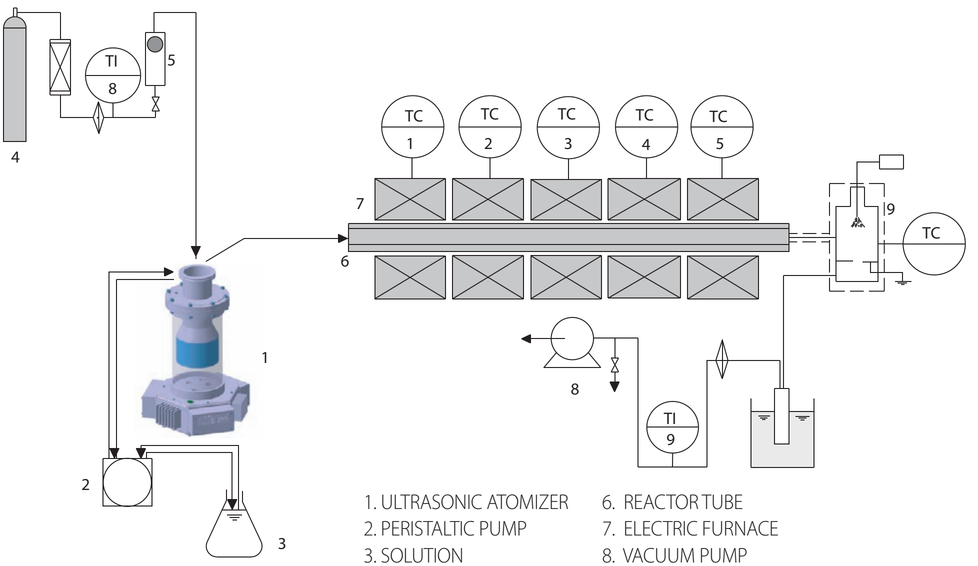
PRIZnano

ULTRASONIC PYROLYSIS ATOMIZER

There is a high demand for nanomatarials of various kind and properties. During last decades a lot of methods for nanomaterials production are developed. Some of them starts from liquid precursor transforming it to spray and producing solid particles in hot reactor. These methods are known as spray pyrolisis methods. The basic idea is to produce small liquid aerosol particles, to dry it and produce smaller solid particles. It is possible to integrate precipitation, aerosol production, thermolysis and sintering in one continuous process suitable for laboratory or industrial purposes.

The first step in all spray pyrolisis methods is atomization of liquid precursor to small liquid aerosol particles. There are various methods for aerosol production: pressure, air, electrostatic, centrifugal and ultrasound, all distinguished by size, volume and speed of produced aerosol particles. Common property of all aerosol production methods is that after aerosol formation surface tension maintenance spherical shape and resists further spreading of aerosol liquid particles.

Generated aerosol can be mixed with carrier gas and conducted through hot reaction zone. During passage of aerosol through hot reaction zone, each of aerosol particles act as a micro-reactor containing solvent, dissolved material and carrier gas. Also, during passage, solvent will react or escape aerosol particles, but material solluted in aerosol particles will stay in formation, first in form of micro porous particle of defined phase composition and finally in form of sintered dense particle. Because of drying, aerosol particles will shrink in mass and size. Smaller concentration of material dissolved in liquid lead to smaller size of finally produced solid nanoparticles [1].



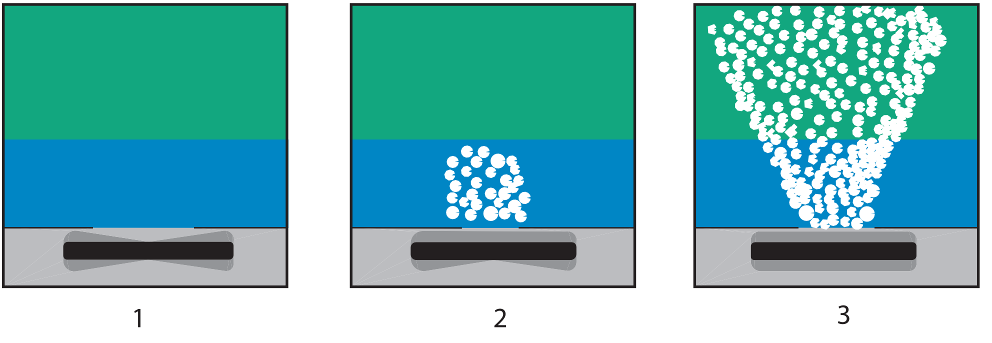
1. ULTRASONIC ATOMIZER
2. PERISTALTIC PUMP
3. SOLUTION
4. CARRIER GAS
5. FLOW METER
6. REACTOR TUBE
7. ELECTRIC FURNACE
8. VACUUM PUMP
9. ELECTROSTATIC PRECIPITATOR

Spray pyrolisis allows complete maintenance of stoichiometry at aerosol droplet level and is very convenient for synthesis of mixed metal oxides. Besides, synthesis of nonoxide ceramics, metallic and composite nanoparticles is possible by controling of thermolytic reaction in gas or solid phases of synthesis process. As all aerosol particles are subject to the same reaction conditions (speed of aerosol through reaction zone, temperature, time in reaction zone, pressure, surrounding gas), it is possible to maintain homogeneity of substances in all phases of process, from liquid to final solid particles.

Depending of used solvent, precursor material, carrier gas and reactor temperature it is possible to produce particles of various morphology (dense, hollow, porous, spherical, cylindrical, irregular, etc).

Thanks to the direct transformation of liquid to solid particles of required phase composition, size and shape, often additional process steps as calcinations and grinding are not necessary.

The ultrasound generation of aerosols is well known methods for creation of aerosol. Ultrasound generation of aerosols is well suited for the continous production of low size liquid particles. The principle of the method is use of submerged source of high frequency ultrasound and focusing of generated ultrasound energy to region near liquid surface. If energy of ultrasound is sufficient, aerosol above surface of liquid will be created. Diameter of aerosol particles is function of liquid surface tension, liquid density and ultrasound frequency. Higher values of surface tension and tension and lower values of liquid density lead to smaller size of aerosol particles [1]. Ultrasound frequencies of 0.5 MHz, 1.3 MHz, 1.8 MHz and 2.4 MHz are some of often used values.



1. Vibration 2. Cavitation 3. Misting

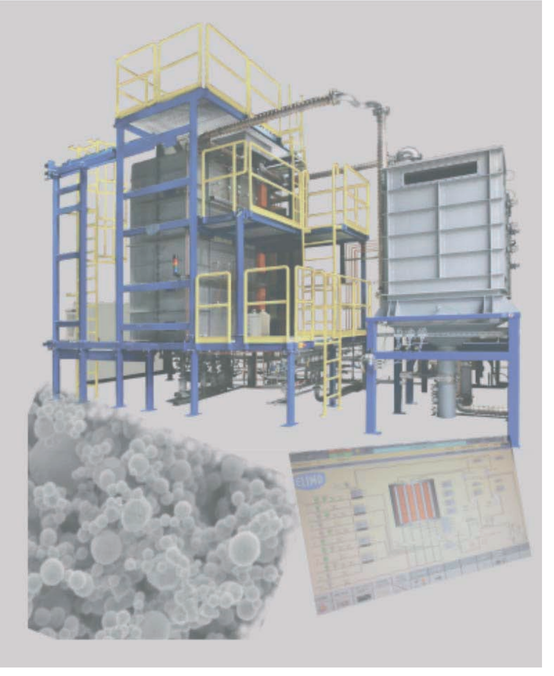
Historically, ultrasound generation of aerosol was not used often in industry because of low volume of produced aerosol. But this method has advantages such as low dispersion of produced aerosol particles and continuously adjustable volume of aerosol production.

PRIZMA has two decades of experience in design and use of ultrasound atomization in various medical and industrial devices. A slightly modified PRIZMA medical ultrasonic atomizer was used in laboratory experiments conducted at Aachen RWTH-IME Process Metallurgy and Metal Recycling few years ago. Obtained results were promising, good quality and small dispersion of produced aerosol is confirmed [2].

When RWTH-IME Process Metallurgy and Metal Recycling started scaling-up of laboratory process, they requested high volume of aerosol. Ultrasound atomizers are not known as productive devices, but because of previous experience and knowledge, after query from RWTH-IME Process Metallurgy and Metal Recycling, PRIZMA decided to overcome main problem of ultrasound aerosol generation and to develop ultrasound liquid atomizer capable to fulfill requirements defined by RWTH-IME Process Metallurgy and Metal Recycling.

Those requirements were:

- transformation of more than 1 liter of liquid to aerosol per hour per atomizer,
- small dispersion of produced aerosol particles,
- continuous regulation of aerosol volume production,
- chemical resistant construction,
- use of various carrier gasses,
- easy integration with liquid, gas, power supply and control installation of the plant,
- easy usage,
- easy maintenance.



A result of our development is compact PRIZnano ultrasonic pyrolisis generator with dimensions of 300x300x450 mm and weight of 3 kg.

Atomizer can be powered from AC power supply of 110 V to 240 V, 50 Hz or 60 Hz, and maximum power consumption is 150 W.

All parts coming in contact with chemicals are made of plastics (PTFE, PE, PC) and they are compatible with most chemicals and gasses.

Maximum atomizing capacity of more than 1.2 liters per hour is achieved by use of 3 glass coated piezoelectric transducers. Volume of produced aerosol is continuously adjustable from zero to maximum by external control DC voltage in range 0 to 10 volts or 0 to 24 volts.

Due to required small size of aerosol particles, ultrasound frequency of 1.7 MHz is chosen. Other frequencies of ultrasound are also available.

High efficiency requires regulation of liquid in atomizer chamber and therefore atomizing system is equipped with liquid level sensors and electronics for interfacing with external liquid maintenance system.

To transport aerosol from atomizer chamber to reactor it is necessary to have carrier gas supply. Gas supply is possible through threaded hole connection.

Connection with reactor is via standard flange easy for assembly and disassembly.

References

[1] The ultrasound generation of droplets for the production of submicron size particles, J. Charauau, P. Tierce, M. Birocheau, J. Aerosol Sci., Vol. 25, Suppl. 1, pp. S233/234, 1994.

[2] Nanosized metallic oxide produced by Ultrasound Spray Pyrolisis, J. Bogovic, S. Stopic, B. Friedrich, J. Schroeder, Proceedings of EMC 2011.

[3] "Characterisation of cathode materials LiMn2-xMxO4 (M=Mn, Cr, Zn) synthesised by ultrasound spray pyrolysis", D. Jugovic, Master's thesis, University Belgrade, Faculty of physical chemistry, 2004.

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