

Initial development of a high-performance filtration device with Vapor-Phase Axial Deposition Process.

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Abstract

The Vapor-Phase Axial Deposition Process was studied in order to evaluate its capacity for producing high porous nanomaterials, which could be used for filtration processes. An initial device was developed with this technique, and a micropore with diameter of $1,0 \pm 0,1 \mu\text{m}$ was obtained, in a material combining nanosilica with nanotitania particles.

Key words:

VAD, porous material, nanomaterial.

Introduction

A high-performance filtration device, such as a membrane, is one which can separate a fluid, the filtrate, from dissolved components, such as ions, macromolecules, suspended solids, and bacteria, and are commonly manufactured from porous materials^[1]. This work consists in the study of the parameters of the Vapor-Phase Axial Deposition (VAD) process, in order to manufacture a porous material by the deposition of amorphous silica nanoparticles on a substrate's surface.

Results and Discussion

The VAD method was initially developed for the optical fiber preforms production, allowing to manufacture high-transparency vitreous silica, with no presence of bubbles and precise control of the fiber's geometry and refractive index^[2].

The amorphous silica nanoparticles deposition process, shown in **Image 1**, is initiated by a high-temperature H_2 - O_2 flame in the presence of the reagent SiCl_4 , which reacts and produces silica nanoparticles (SiO_2). These particles are deposited on a silica stick which spins with constant angular velocity inside an oven chamber. The stick also does a vertical translation inside the chamber, and the translation velocity is controlled by a feedback control system. The parameters that directly influence the process are the H_2 , O_2 and SiCl_4 fluxes, the distance between the stick and the flame, the translation velocity, and the presence of other reagents, such as TiCl_4 ^[3].

Silica nanoparticles were deposited in porous ceramic substrates, using different VAD process parameters combinations for the determination of which parameters combination results in the smallest pore diameter. Then, the materials were analyzed with scanning electron microscopy technique, and the images were processed with the software Matlab2013, in order to evaluate the average pore diameters, which are summarized in **Chart 1**. Image 2 shows sample C, the one with the smallest pore diameter obtained, $1,0 \pm 0,1 \mu\text{m}$ and its scanning electron microscopy. This sample was manufactured using TiCl_4 for also producing titania nanoparticles.

Chart 1. Average pore diameters of the samples.

Sample	A	B	C	D
Pore diameter (μm)	$2,6 \pm 0,3$	$2,2 \pm 0,2$	$1,0 \pm 0,1$	$1,7 \pm 0,2$

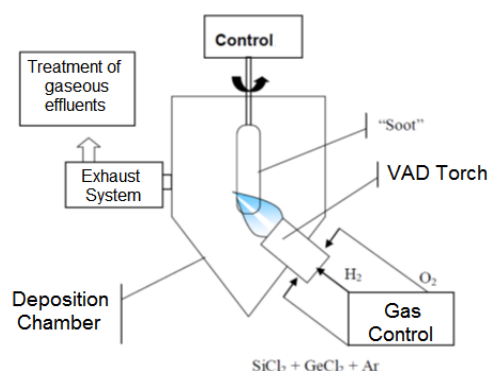


Image 1. VAD process, for silica nanoparticles deposition.

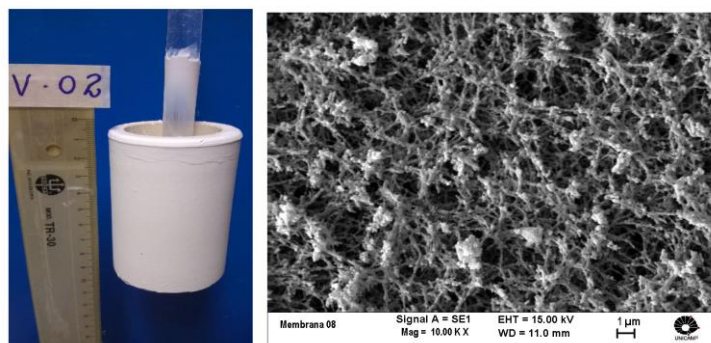


Image 2. (Left) Sample C after the manufacturing process; (Right) Scanning electron microscopy of Sample C's surface.

Conclusions

The VAD method is capable of producing nanomaterials with high porosity, which can be used as a water-purifying membrane. New analysis should be done for allowing the use in real processes, such as BET analysis for evaluating the material surface area and its permeability.

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