SYNTHESIS AND AGING OF AEROGELS FOR CHERENKOV COUNTERS

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AGENDA

- What is?
- Sol-Gel Method
- Drying Process
  - Methods of SCD
- Aerogel Characteristics
- Applications
  - Cherenkov Radiation
- Synthesis Process
  - Sinthesis & Aging
- Summary
- References

WHAT IS?

- In 1932, Kistler synthetized the silica aerogels.
- Description:
  - "Open, cross-linked silica structure with a high fraction of void with extremely fine pore sizes" [1].
  - "A low-density open cell foam with large internal void space" [2].

The aerogel are versatile materials that are synthesized using the Sol-Gel method at low temperature [3].

SOL-GEL METHOD

- Based on the hydrolysis and condensation of the precursors.
  - Sols: Solution with colloidal particles suspended
  - Gel: Its formed by an interpenetrating networks.
    - Solid phase/Solvent phase
- Advantage: Control the pore-solid arquitecture [4]
  - Mesoporous of 2-50nm
  - Inorganic or Inorganic/Organic framework

SOL-GEL METHOD (CONT.)

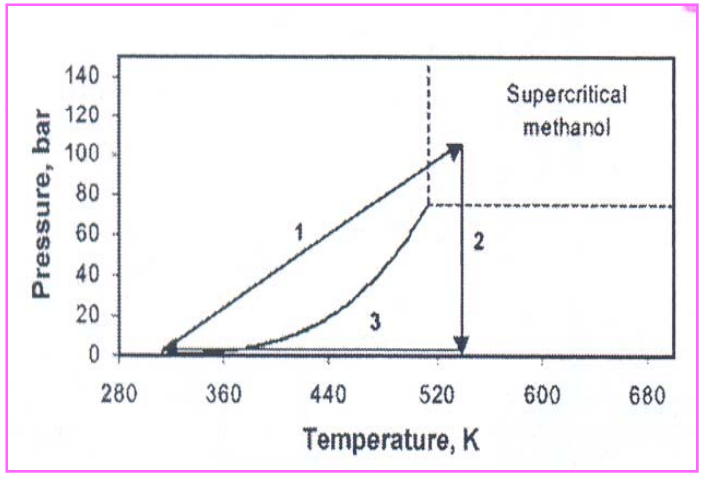
- Used to synthesized different materials as:
  - Silica based materials
  - Non-silica based materials
  - Biological materials
  - Porous materials
  - Optical materials

DRYING PROCESS

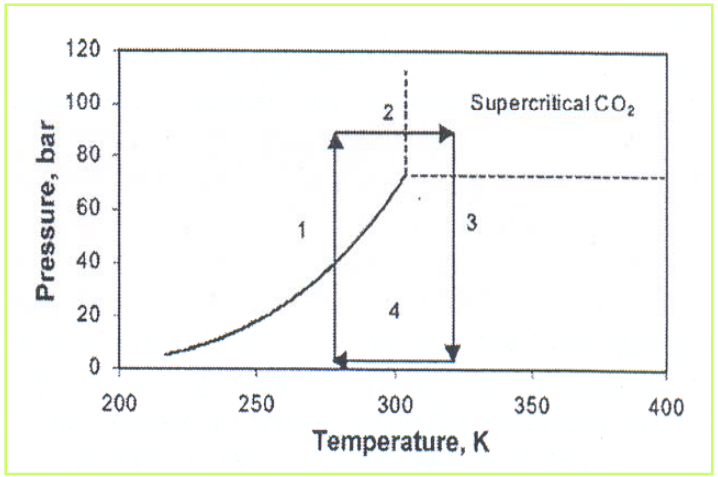
- Determine the type of material and its characteristics.
  - Xerogel:
    - The drying process is done by an evaporation method.
  - Aerogel:
    - The drying process is done by supercritical techniques.

METHODS OF SUPERCRITICAL DRYING:

- High Temperature Supercritical Drying (HTSCD)
- Low Temperature Supercritical Drying (LTSCD)



Schematic procedure of low temperature supercritical drying.



Schematic procedure of high temperature supercritical drying.

Reference: Soleimani-Dorcheh, A. & Abbasi, M.H. **Silica aerogel; synthesis, properties and charcterization.** *Journal of Materials Processing Technology*.2008. 199. pp.10-26.

AEROGEL CHARACTERISTICS

- The aerogels exhibits [1, 2] :
  - Very high surface area
  - Low refraction index
  - Low thermal conductivity
  - Low sound velocity
  - Visible transparency
  - High acoustic impedance

APPLICATIONS OF AEROGELS AND XEROGELS

Some applications for this material are [1,6,7] :

- Insulation transparent glazing
- Thermal insulation tiles
- Cherenkov radiation detectors
- Catalyst supports
- Filters and membranes
- Acoustic delay lines
- Oxide ceramic precursors
- Biochemistry area
  - Enzyme's encapsulation, especially lipases .

CHERENKOV RADIATION

- In 1934, Pavel Cherenkov observed the effect of a blue glowing of radioactive materials in liquids.
- The phenomenon was explained by Ilya Franc and Igor Tamm.
- The Cherenkov radiation can be used to measure the speed and direction of particles traveling in a medium.
- This effect is used to study the production of particles during collisions, cosmic rays detections and distinguishing between different types of neutrinos and electrons [7].

CHERENKOV RADIATION

- The speed of light in a medium is less than the speed of light in the vacuum.
  - According to that, the refraction index (*n*) is always greater than 1.
  - This makes possible that a particle's speed exceeds the speed of light traveling in the same media [7, 8] .
- When a charged particle travels in a media, a radiation is produced as a continuous spectrum.
  - For example, if a charged particle travels in water (as a media) the water molecules can be excited and photons are emitted to return to their ground state.
  - Because the speed of the particle is higher than the light in the water a continuous flow of photons are emitted with a constructive interference to form a visible blue glow, *the Cherenkov effect* [7, 8] .

The Cherenkov effect is used to determine the momentum, direction and magnitude of radiation emissions [7, 8] .

OBJECTIVE

The objective of this investigation is the development of a novel technique to perform and enhance the synthesis and aging of the aerogel to maximize their straight and superficial area to capture the particles produced during the Cherenkov radiation effect.

SYNTHESIS

- Commonly, the aerogel are composed by inorganic networks of metals and semimetal oxides nanoparticles, as silica but organic aerogels could be synthesized.
  - For example, resorcinol-formaldehyde aerogels are the most common organic aerogels [2] .
- Hydrophobic silica aerogels could be synthesized principally by two methods.
  - Use of Tetramethoxysilane (TMOS) or Tetraethoxysilane (TEOS) as a precursor.
    - The removal of the alcohol at high temperature produces a hydrophobic gel.
    - The hydrophobicity of the material could be enhancing using Hexamethyldisilazane (HMDS) at temperatures over 200°C [6] .
  - The other method is using TMOS or TEOS in the gelling or co-gelling process with a silicon precursor that contains at least one non-polar side group [6] as Si-CH_3.

SOL-GEL METHOD

- At the beginning:
  - Used a modification of Stöber- Fink-Bohn Method.

Table I. Batch composition for the silica synthesis by means of the hydrolysis of TEOS in an alcohol (methanol or ethanol) in the presence of an amine, or ammonium hydroxide, as catalysts, with and without DDW in the synthesis media, and at two temperatures (300 °[K] and 323 °[K]).

Sample	TEOS [ml]	DDW [ml]	NH_4OH [ml]	Amine [ml]	MeOH [ml]	EtOH [ml]	T [°K]
70bs2-50	0.25	0	0	2.0	0	10	323
70bs2-25	0.25	0	0	2.0	0	10	300
79bs2-50	0.45	0	0	2.5	0	10	323
79bs2-25	0.45	0	0	2.5	0	10	300
68C-25	0.50	1.5	2.0	0	10	0	300
70E-25	2.40	0	6.0	0	30	0	300
81-25	1.5	0	6.6	0	30	0	300

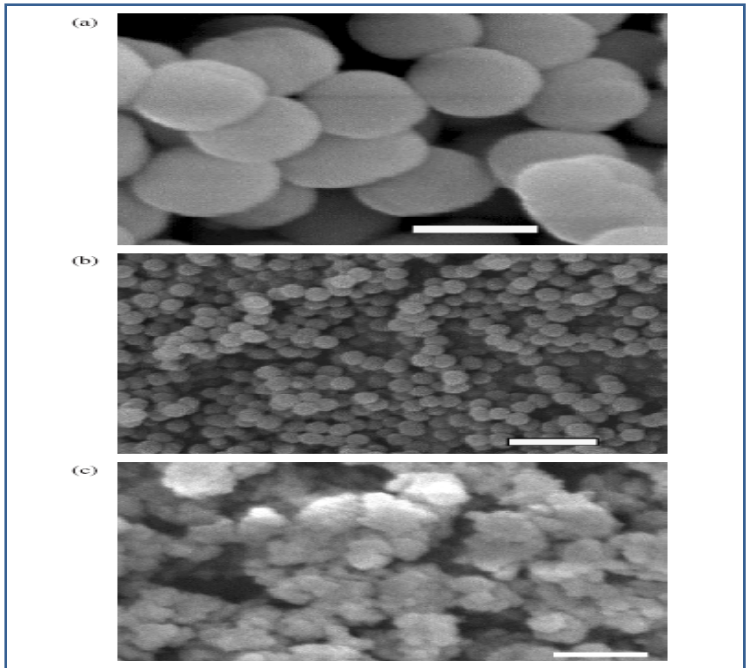
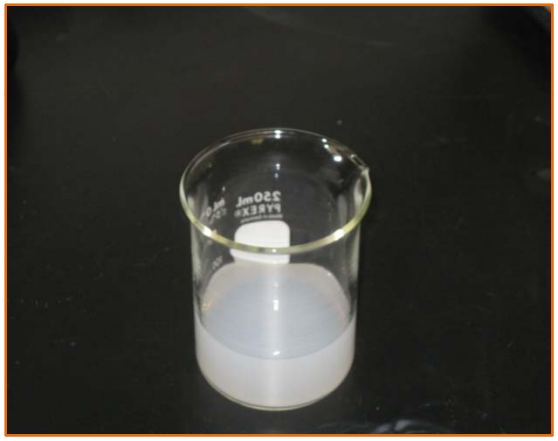


Fig. 1. SEM micrographs of samples (a) 70E-a-s (Bar = 1,000 nm), (b) 81-a-s (Bar = 1,000 nm) and (c) 70bs2-25-a-s (Bar = 500 nm). Reprinted with permission from [5], S. McIntosh and R. J. Gorte, *Chem. Rev.* 104, 4845 (**2004**), © (2004).

Roque-Malherbe, R. Marquez-Linares, F. Del Valle, W. Thommes, M. **Ammonia Adsorption of Nanostructured Silica Materials for Hydrogen Storage and other Applications.** *Journal of Nanoscience and Nanotechnology.*2008. 8. pp.1-10

GELATION & AGING

- Aging Time:
  - Few hours to Weeks



Gelation time

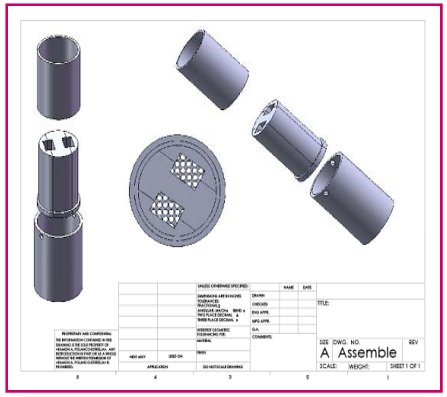
48 hours Aging

168 hours Aging
(1 week)

DRYING PROCESS

- Xerogel
  - Dried at 70°C

- Aerogel



SYNTHESIS AND AGING METHOD SUMMARY

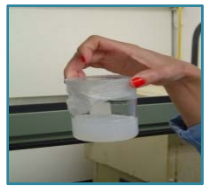
Drying Process
(Xerogel /Aerogel)

Gel & Aging

Condensation
(Silica Source)

Solutions
(Solvents & Catalyst)

SUMMARY



- From February 2008 we are synthesized and aging some samples to be drying as an aerogel, xerogel or by evaporation at room temperature.

Modifications	Synthesis Reagents (at different Molar Quantities)			Gelation Process	Aging Time	Pretreatment	Drying Process
	Solvent	Catalytic (Ammine)	Precursor (Silica Source)				
	EtOH	TEA	TEOS	Uncovered	Few hours	None	Xerogel (70°C)
	MetOH	NH_4OH		Semi-Covered	Weeks	Dried at RT	Evaporation at RT
	H_2O			Totally Covered		Pre-dried at oven	Aerogel

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