

# Use of Ultra-Fine Amorphous Colloidal Silica to Produce a High-Density, High-Strength Grout

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# Research



- Performed by:
- Concrete and Materials Branch
- Geotechnical and Structures Laboratory

- **Grout Requirements**

- **High Density:  $> 2.6 \text{ Mg/m}^3$  (162.3 lb/cu ft)**
- **High Strength:  $> 70 \text{ MPa}$  (10,150 psi)**
- **Ultra-Sonic Pulse Velocity:  $> 3.65 \text{ km/sec}$  (11,975 ft/sec)**

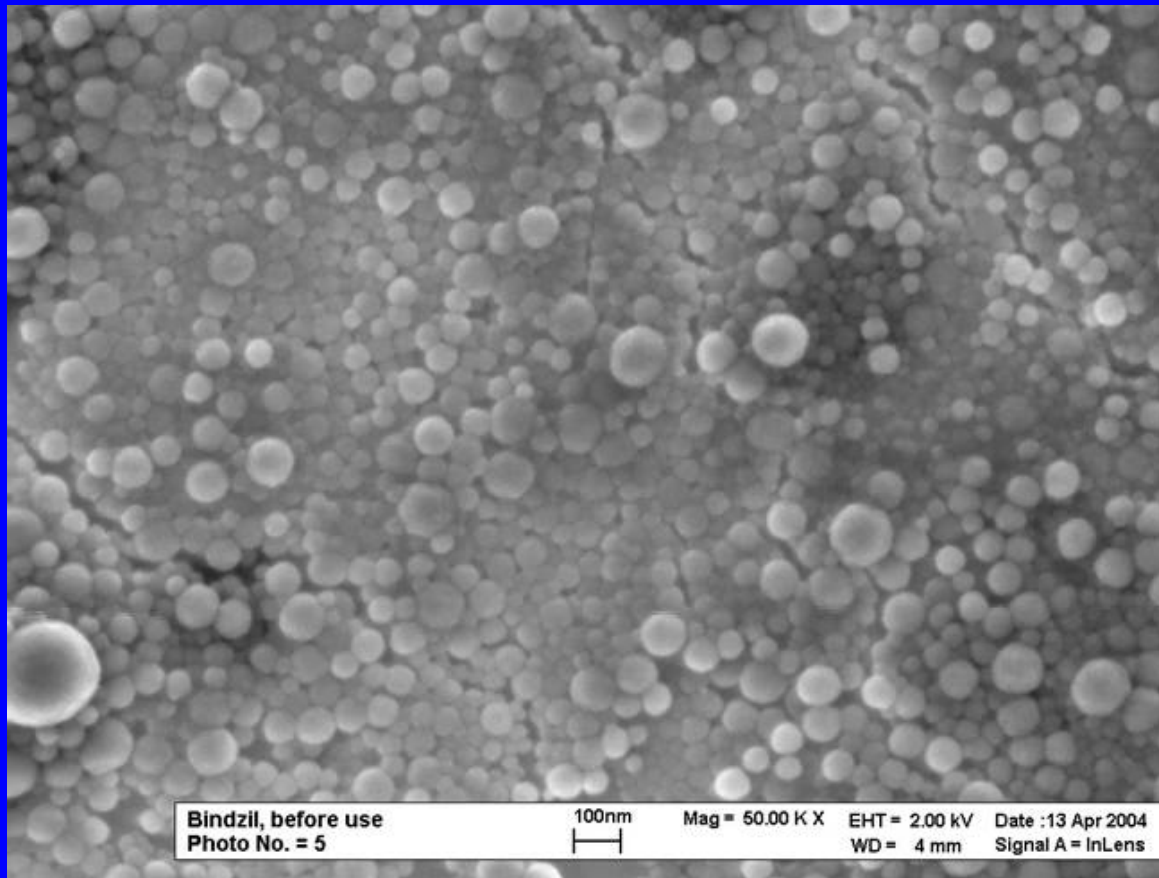
# ***Materials for Grout Mixture***

- **Portland Cement - ASTM C 150, Type I/II**
  - **Lehigh Portland Cement**
- **Hematite Fine Aggregate – ASTM C 637, Grading 1**
  - **Nuclear Shielding Supplies and Service**
- **Silica Fine Aggregate – # 20 to # 40 Sieve Size**
  - **Oglebay Norton**
- **Silica Fume – Low-Carbon, from Production of Zirconia**
  - **Elkem Materials**

# ***Chemical Admixtures for Grout Mixture***

- **High-Range Water Reducing Admixture**
  - **Glenium 3030 NS, Degussa Admixtures, Inc.**
- **Air Detraining Admixture**
  - **D7 Defoamer, Amber Chemical**
- **Ultra-fine Amorphous Colloidal Silica (UFACS)**
  - **Cembinder 8, Eka Chemical, Akzo Nobel**

# Ultra-Fine Amorphous Colloidal Silica



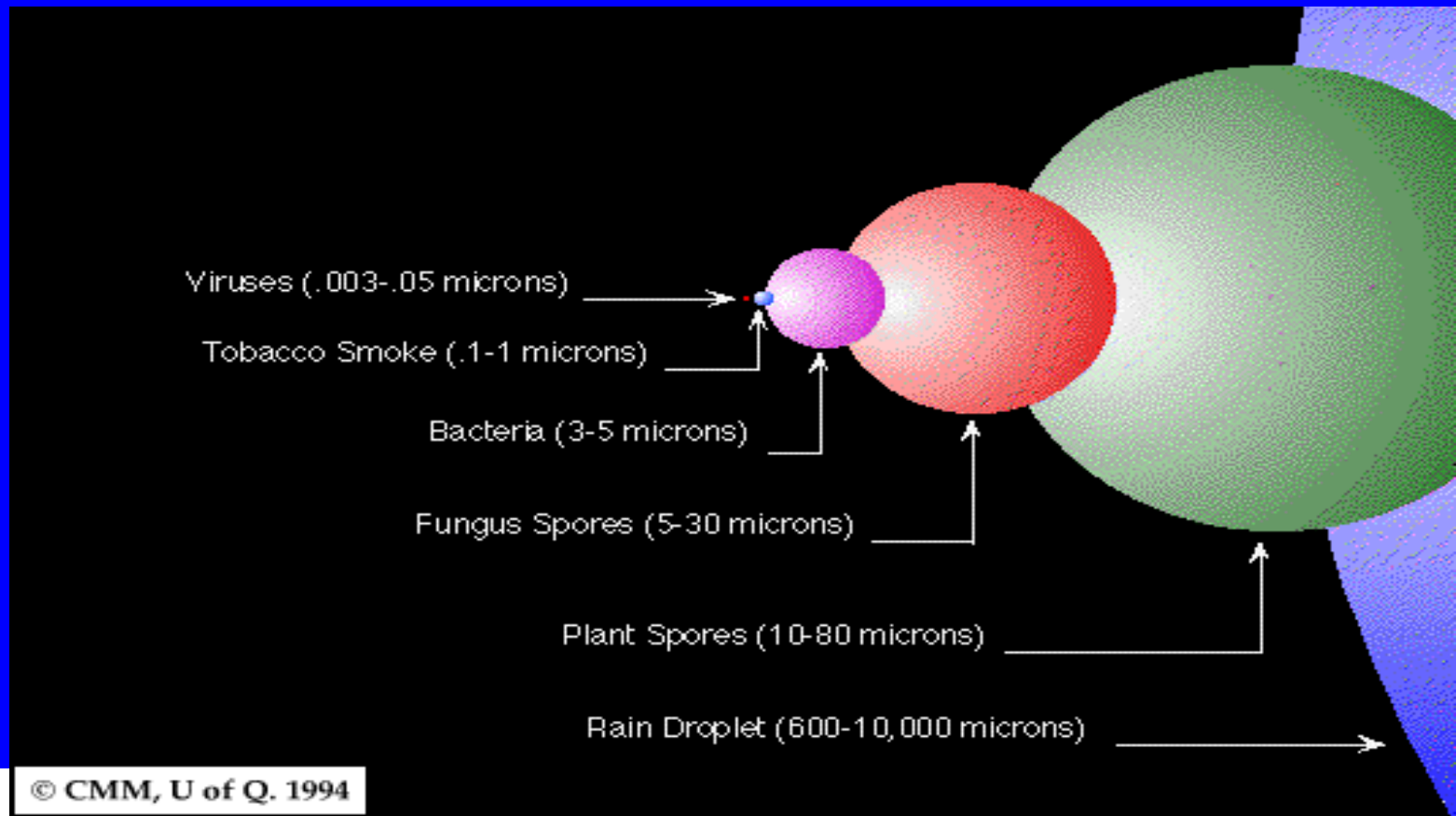
## Ultra-Fine Amorphous Colloidal Silica (UFACS)

- Nano-Silica
- Nano-SiO<sub>2</sub>

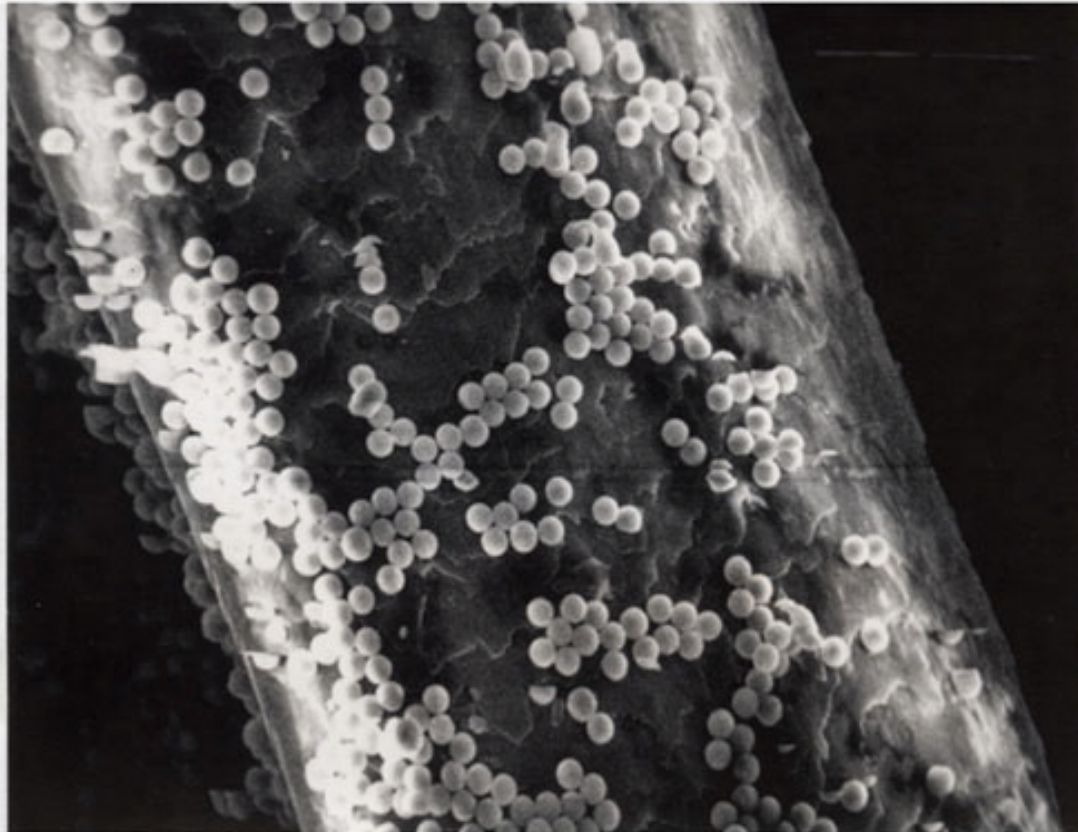
Viscosity Modifier

# Definitions - Ultra-Fine Amorphous Colloidal Silica

- Nano – From the Greek *Nanos* – Meaning “Dwarf”
  - $10^{-9}$  Meter or One *Billionth* of a Meter
  - Nanoscience - 1 to 100 Nanometer Scale



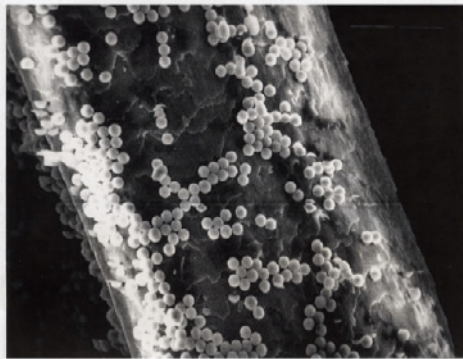
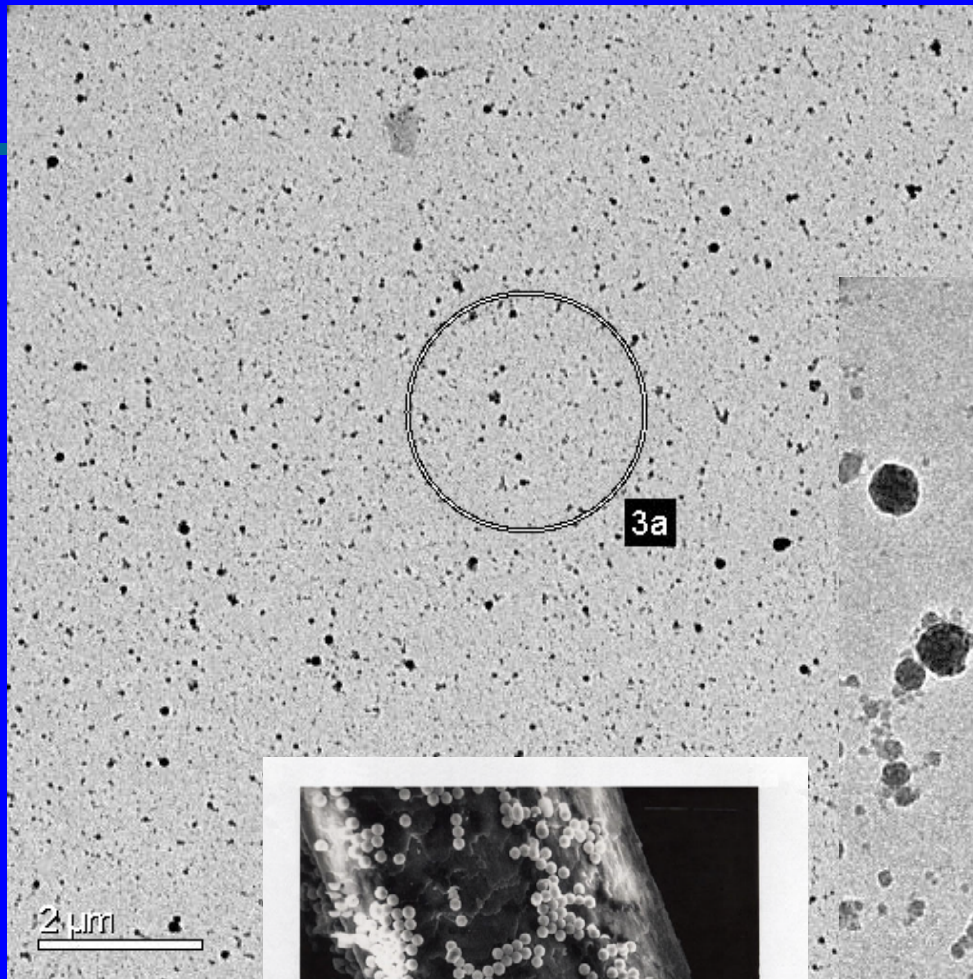
**3.4  $\mu$ m = 3,400 Nanometers!**



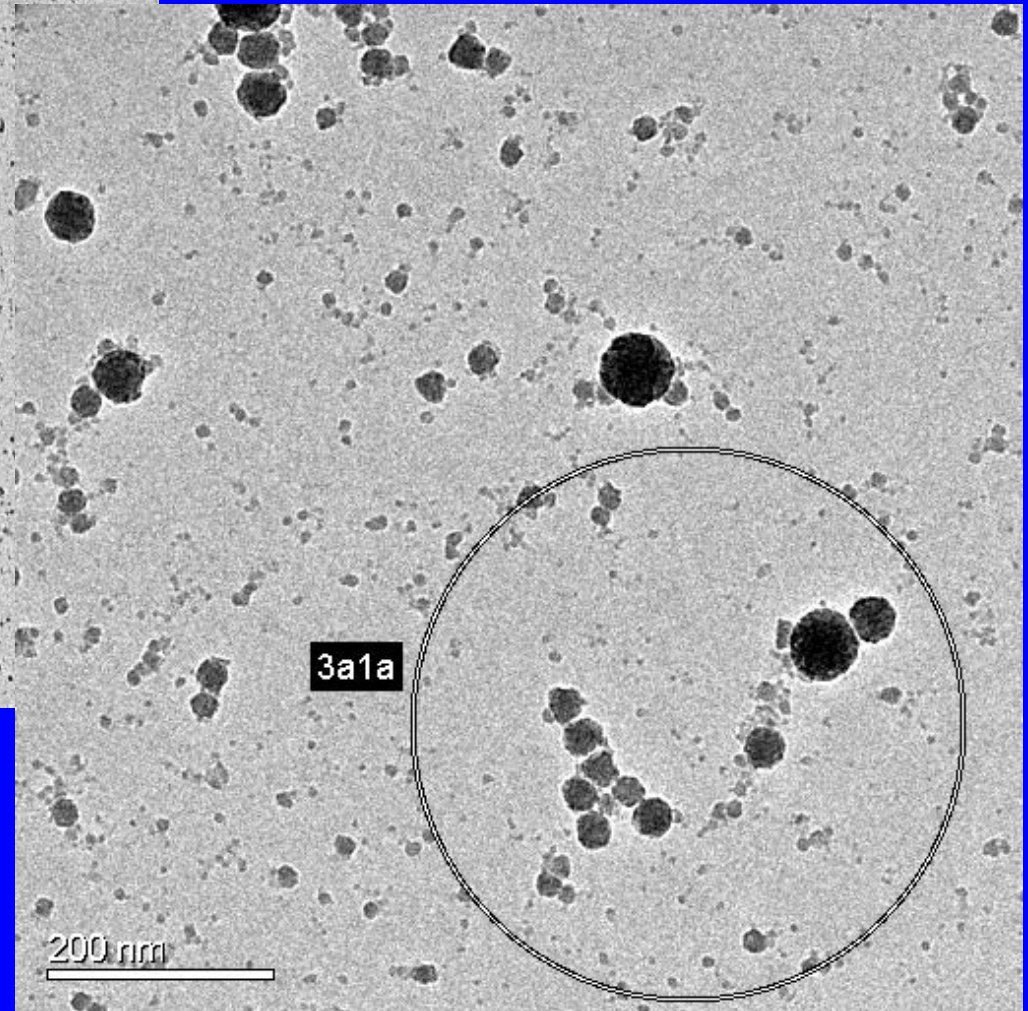
SEM PHOTO of 3.4  $\mu$ m PARTICLES ON HUMAN HAIR, 1000X



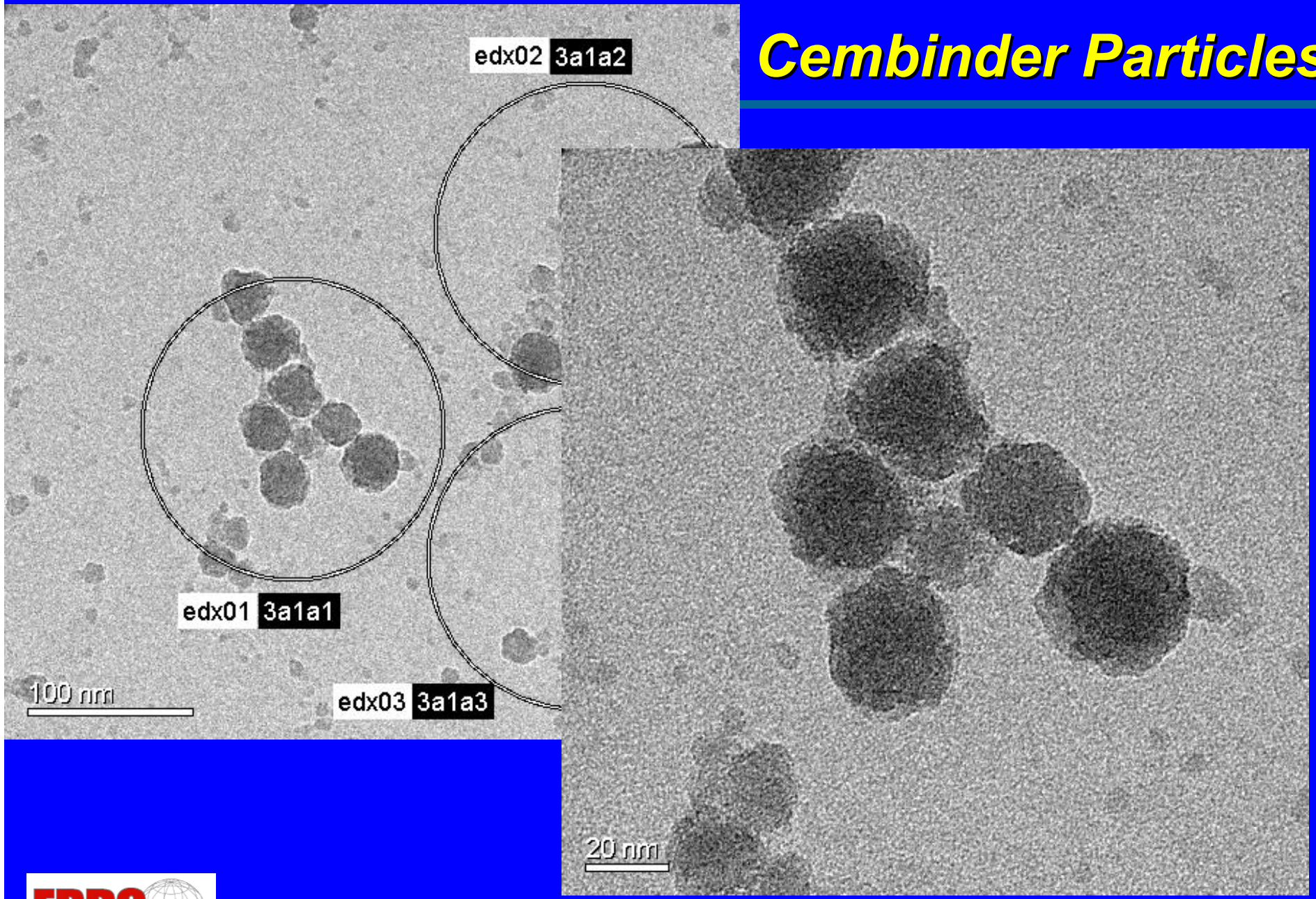
# Cembinder Particles



SEM PHOTO of 3.4 μm PARTICLES ON HUMAN HAIR, 1000X



# Cembinder Particles



## **Definitions - Ultra-Fine Amorphous Colloidal Silica**

- **Amorphous**
  - Non-Crystalline Silica
  - Random Distribution of  $[\text{SiO}_4]^{4-}$  tetrahedra
  - Glass is a Common Amorphous Material

# Definitions - Ultra-Fine Amorphous Colloidal Silica

- **Colloid**

- - Stable dispersion of particles in a medium

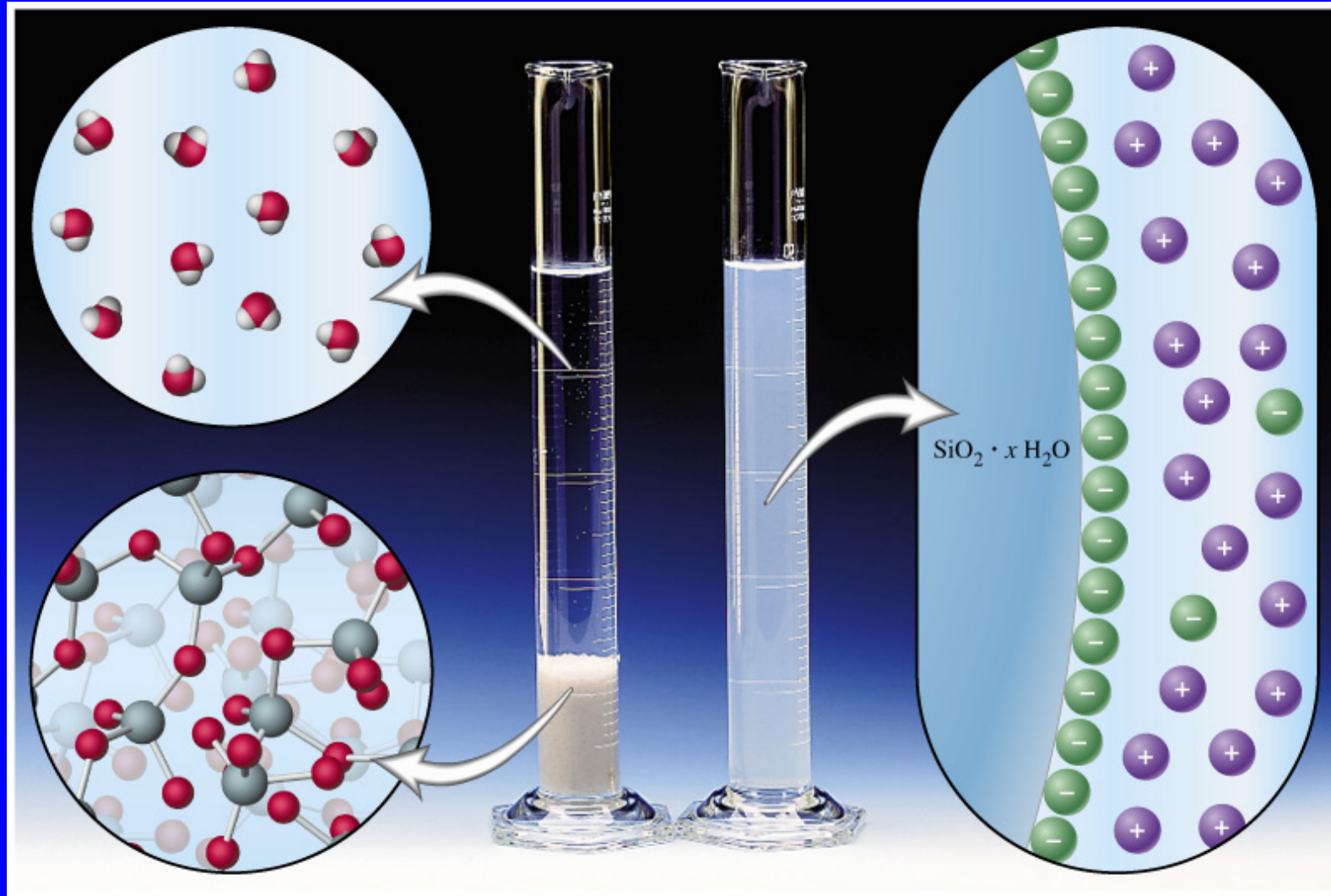
- No settling out!

- Small – Can't be seen with light optics

- $>1$  nm to  $< 100$  nm

- Can't pass through a membrane

# Suspension of Silica Vs. Colloidal Silica



## ***Definitions - Ultra-Fine Amorphous Colloidal Silica***

- **Ultra-Fine Amorphous Colloidal Silica (UFACS)**
  - **Industrially Manufactured**
  - **Liquid Form**
  - **Resembles Skim Milk**

# *Ultra-Fine Amorphous Colloidal Silica*



# ***Ultra-Fine Amorphous Colloidal Silica***

- **Developed for Drilling Applications**
- **Keep Solid Particles in Grout Mixture from Segregating or “Falling Out”**





# Grout Mixer and Pump



# *Grout Consistency*



## ***Grout - Fresh Properties***

- **ASTM C 939 (Flow Cone Method)**
  - 20- 30 Second, Flow Time
- **Wet Density:**
  - ASTM C 938, Section 9.5.1  
(Proportioning Grout Mixtures for Preplaced-Aggregate Concrete)
  - 2.7-2.76 Mg/m<sup>3</sup> (168-172 lbs/ft<sup>3</sup>)

## ***Grout –Hardened Results***

- **Hardened Density: 2.68 Mg/m<sup>3</sup>  
(167.4 lb/cu ft)**
- **High Strength: 71.2 MPa  
(13,230 psi)**
- **Ultra-Sonic Pulse Velocity: 4.40 km/sec  
(14,435 ft/sec)**

- **New Chemical Admixture**
  - **Viscosity Modifying Admixture (VMA)**
  - **Keeps Solids in Suspension**
  - **Does not Decrease Strength**
  - **Reduces Bleed**

# Questions?



## ***Contact Information***

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