

Since 1959



Matter Dreams at Scale:

Creating the Future of Materials

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Chemo-Electro-Mechano Unification for Sustainability

Emerging Science, Technology, and Innovation Conclave (ESTIC), November 3-5, 2025, Bharat Mandapam, New Delhi

Co-founder

InnoNano Research Pvt. Ltd.

InnoDI Water Technologies Pvt. Ltd.

VayuJAL Technologies Pvt. Ltd.

Aqueasy Innovations Pvt. Ltd.

Hydromaterials Pvt. Ltd.

EyeNetAqua Pvt. Ltd.

Deepspectrum Analytics Pvt. Ltd.

Professor-in-charge



International Centre for Clean Water



A close-up photograph of a campfire. Several logs are arranged in a teepee shape, with bright orange and yellow flames rising from the center. The background is dark, making the fire the central focus.

We transform matter with
fire

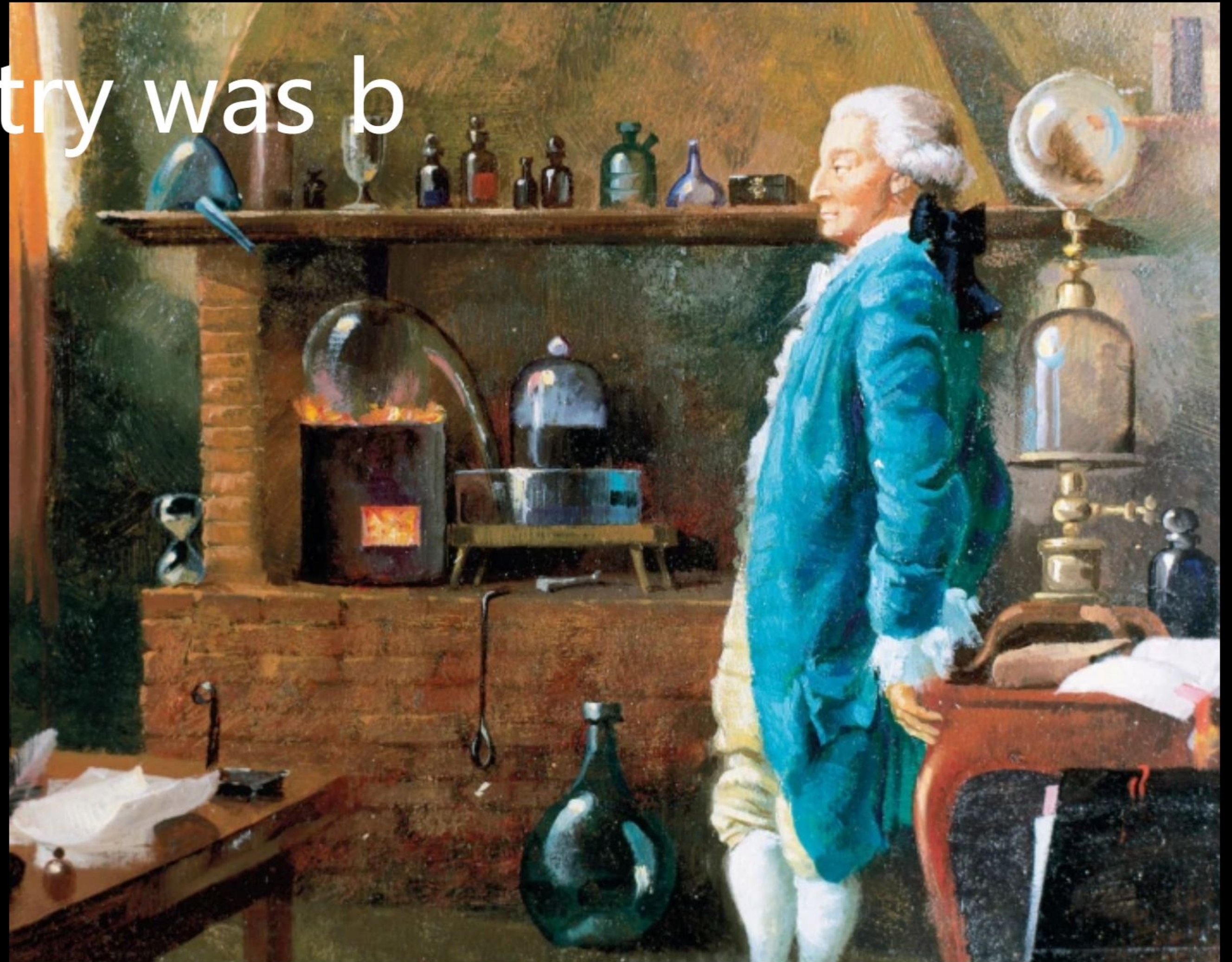
Taming fi
re

Thermodynami
cs

Kinetics

Engineering

Modern chemistry was born



Lowe, D. Laboratory history: The chemistry chronicles. *Nature* **521**, 422 (2015). <https://doi.org/10.1038/521422a>



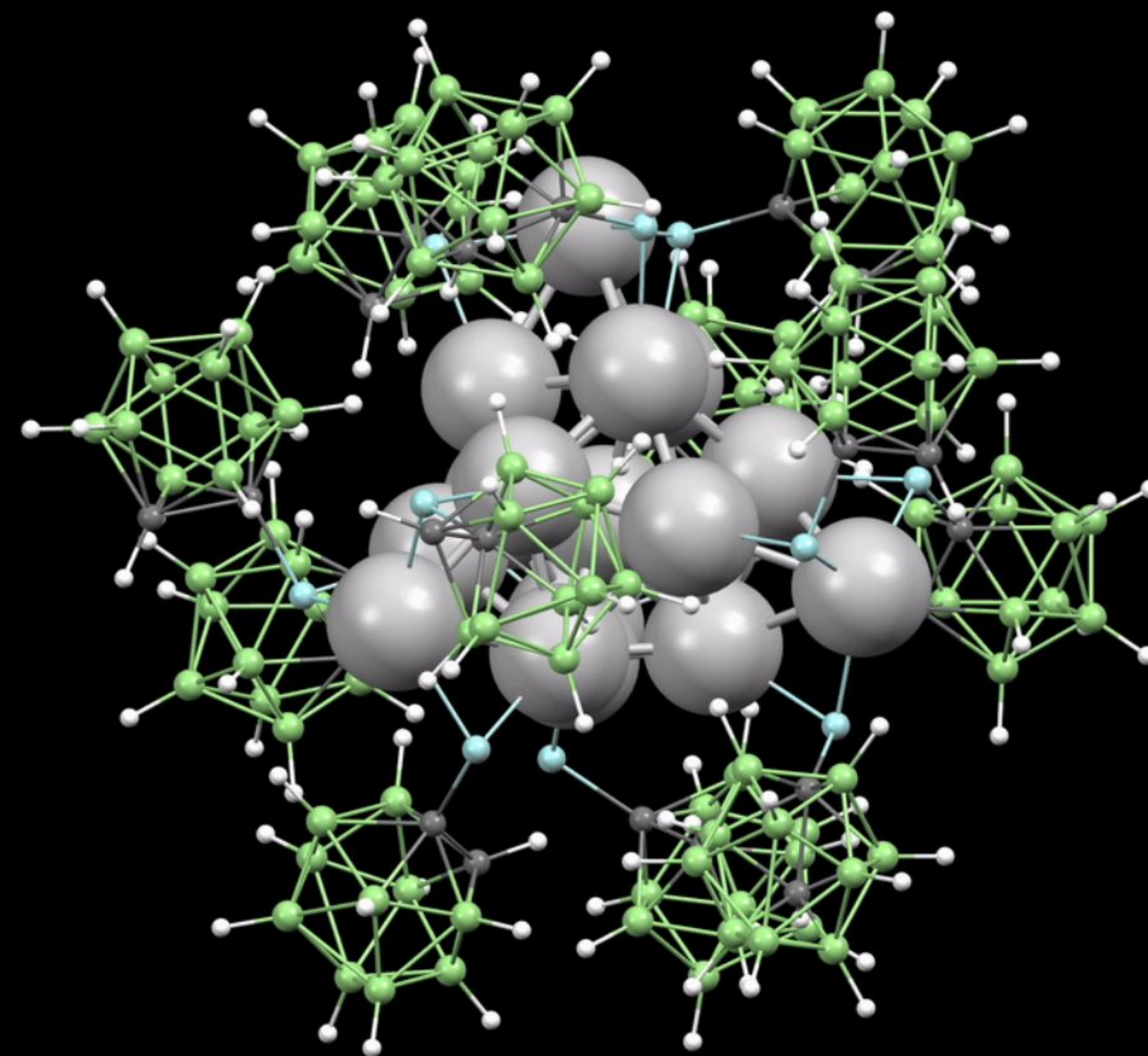
That gave materials and the modern
world

And many problems



<https://www.tatasteel.com/media/23748/tata-steel-crm-complex-jamshedpur.jpg>

But, matter is becoming
ATOMICALLY PRECISE

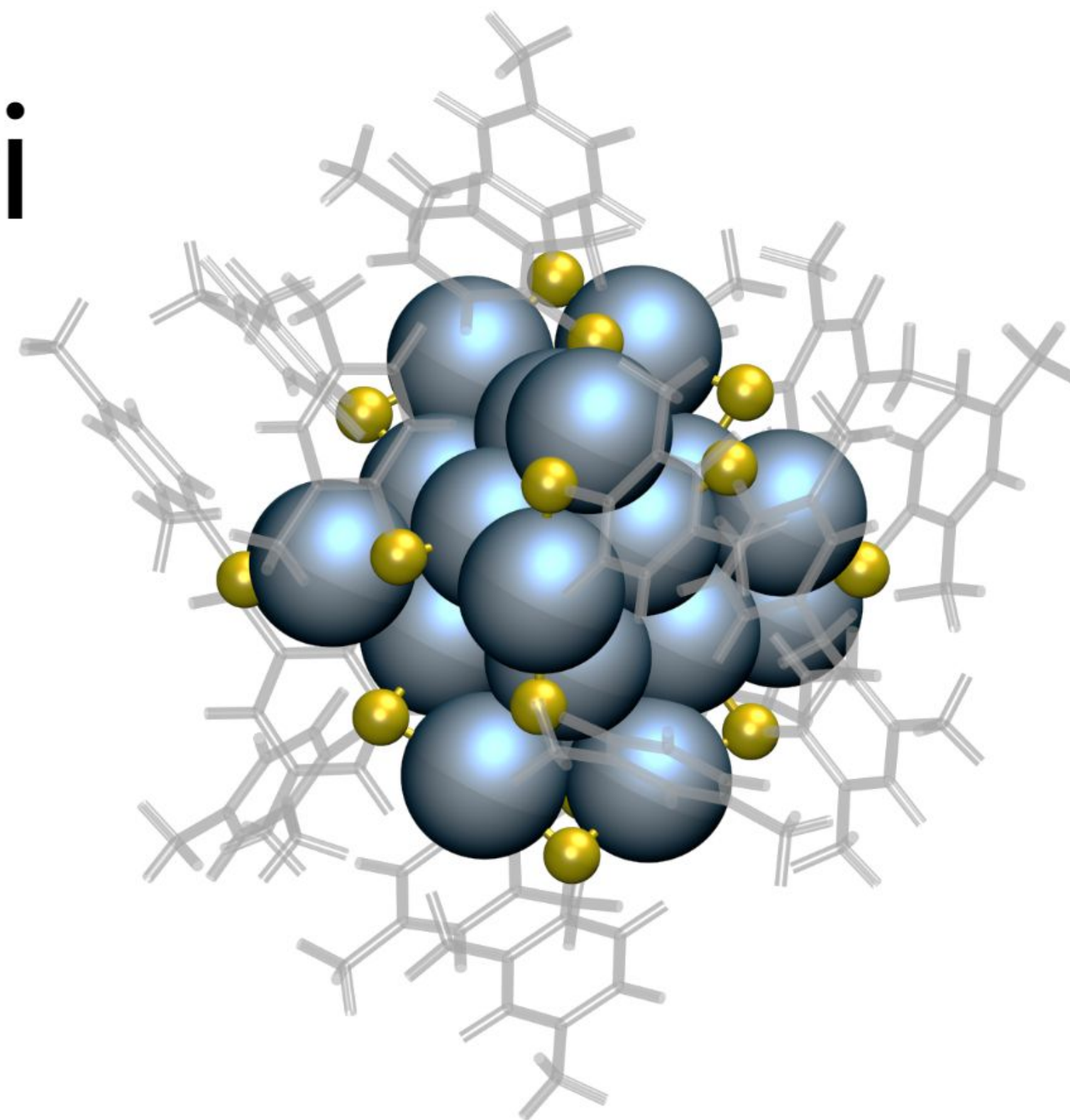


Vivek Yadav, et. al. *Nature Communications*
2025

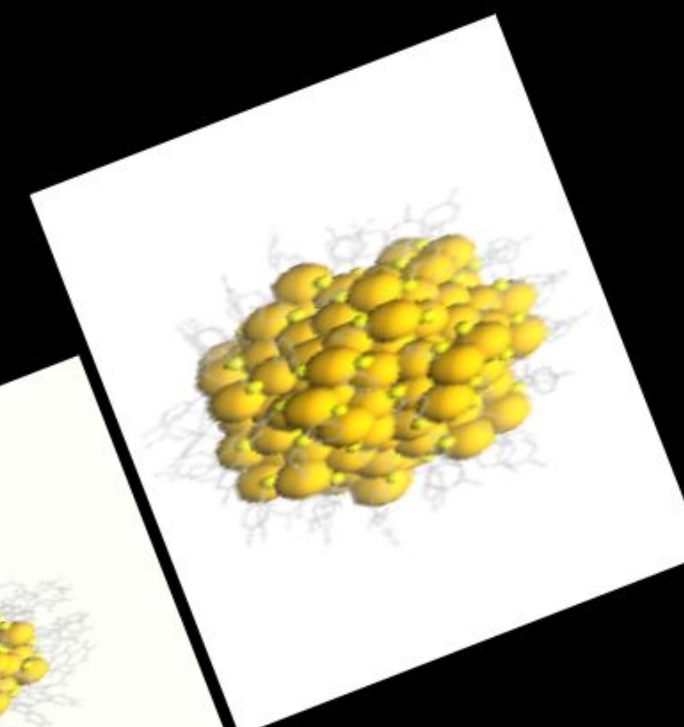
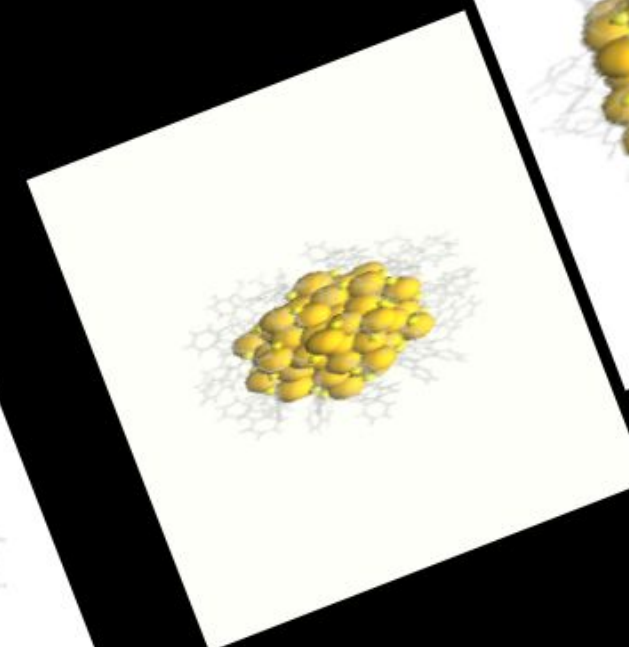
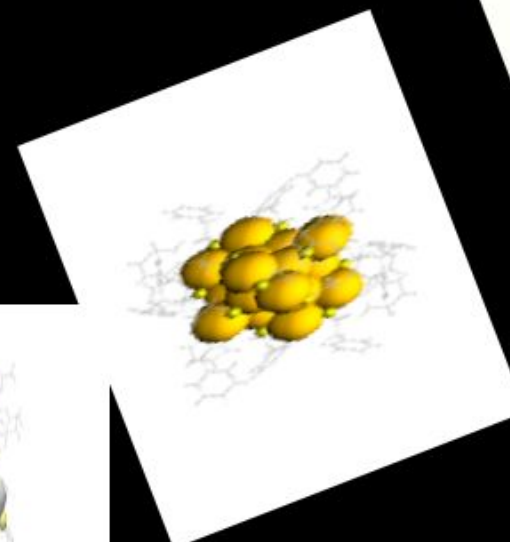
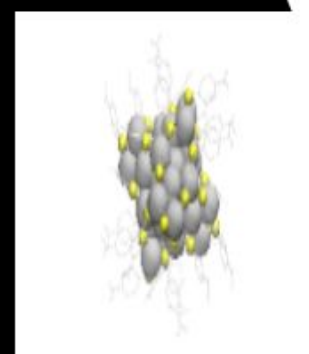
Organic and inorganic matter too are becoming atomically precise

Clusters - Quantum materials

AU25PET18_RES_NEG_MS_3 32 (0.558) Cm (5:80)



Ag₂₉(BDT)₁₂₃- Ag₂₅(DMBT)₁₈- Au₂₅(PET)₁₈-



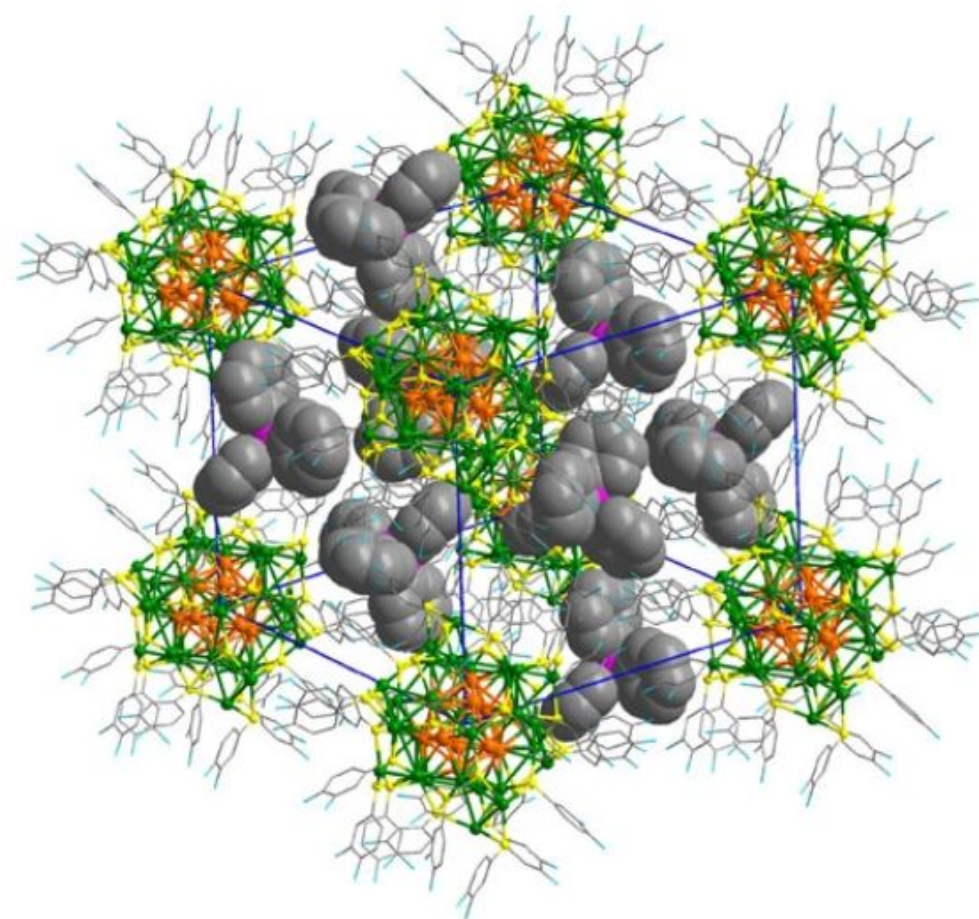
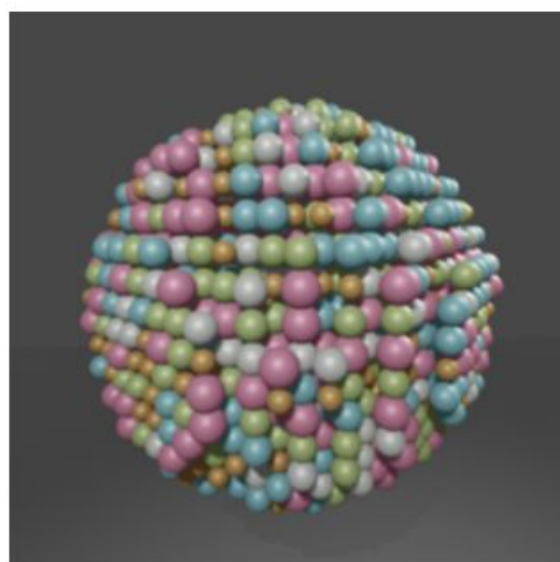
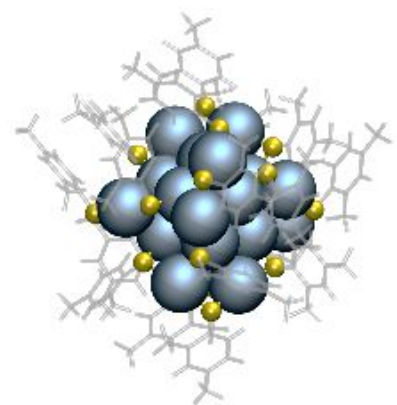
HRMS of Au₂₅(PET)₁₈-

0.2 μ

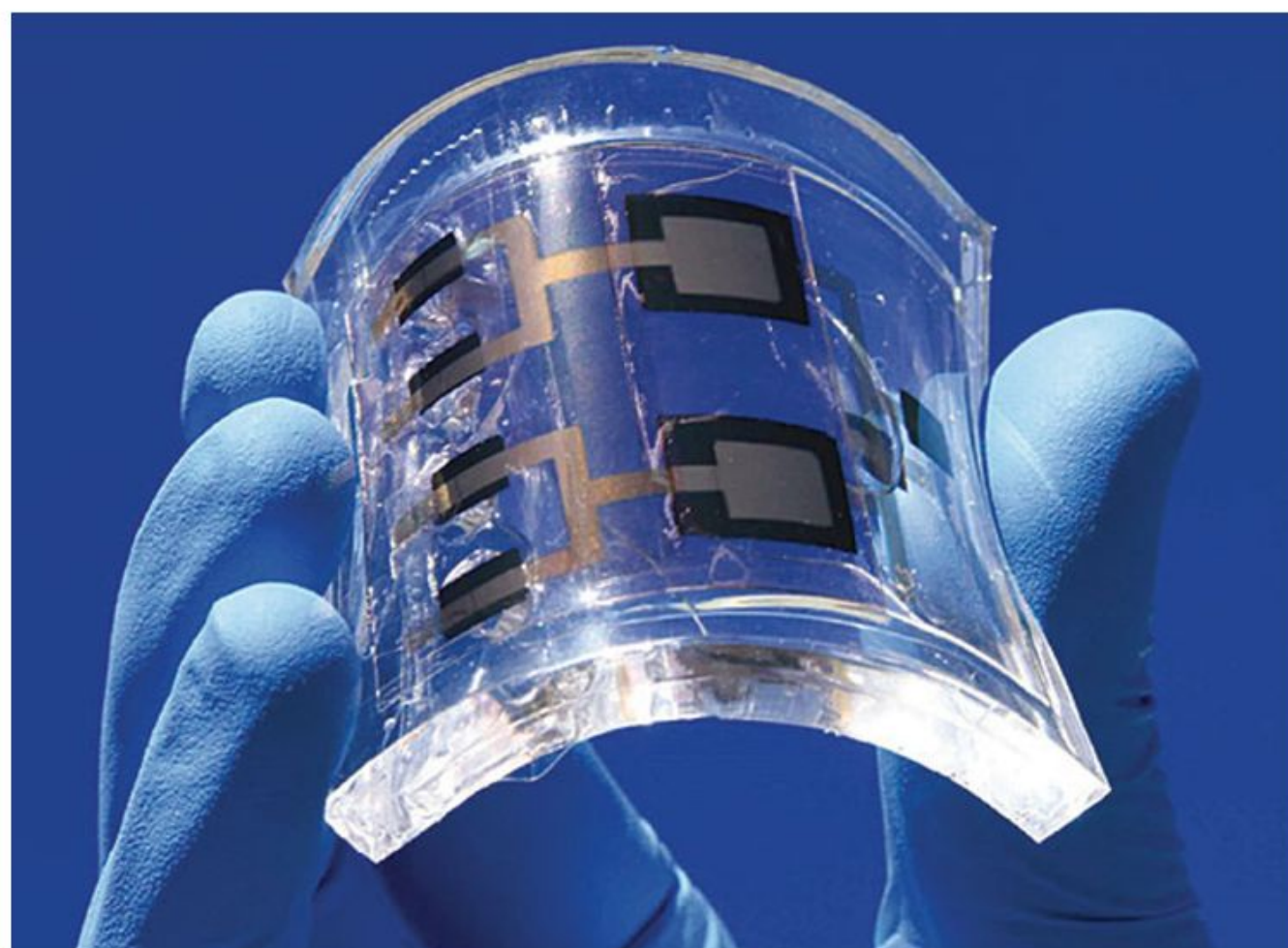
m/z

Semiconductor quantum dots





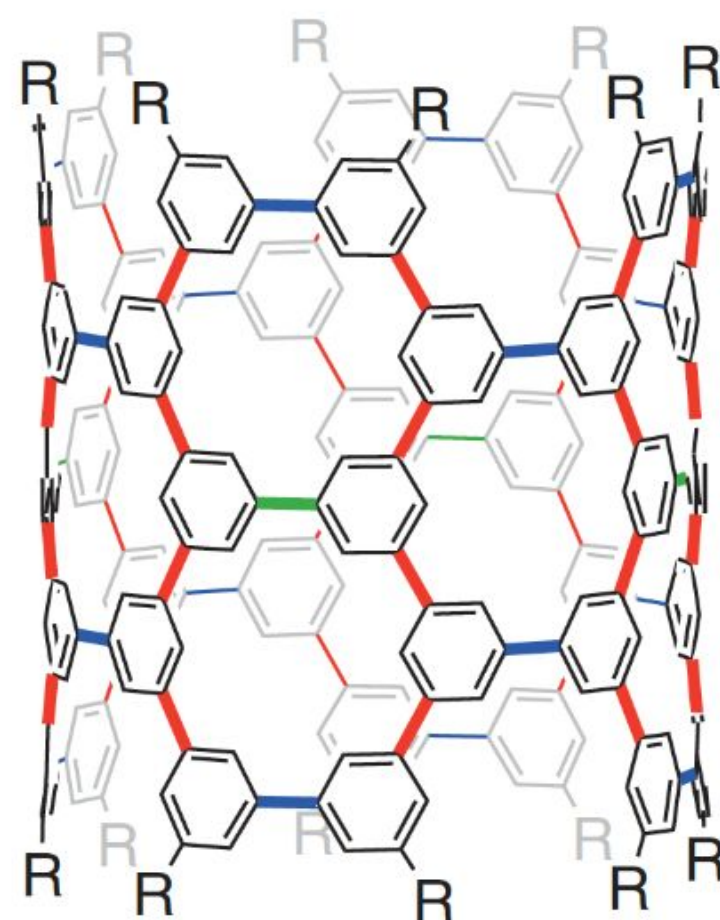
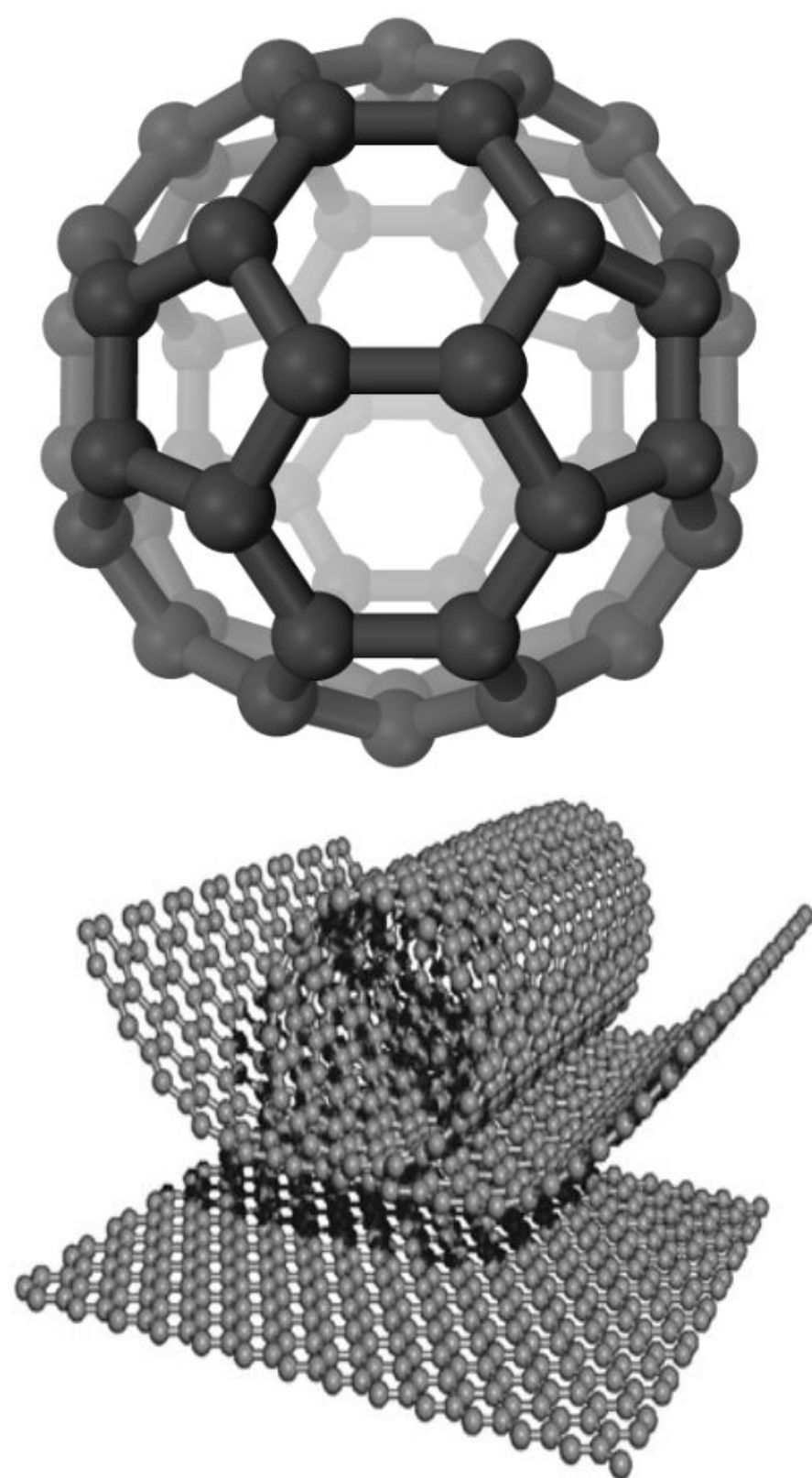
Chasing the 'Cluster' D
reams



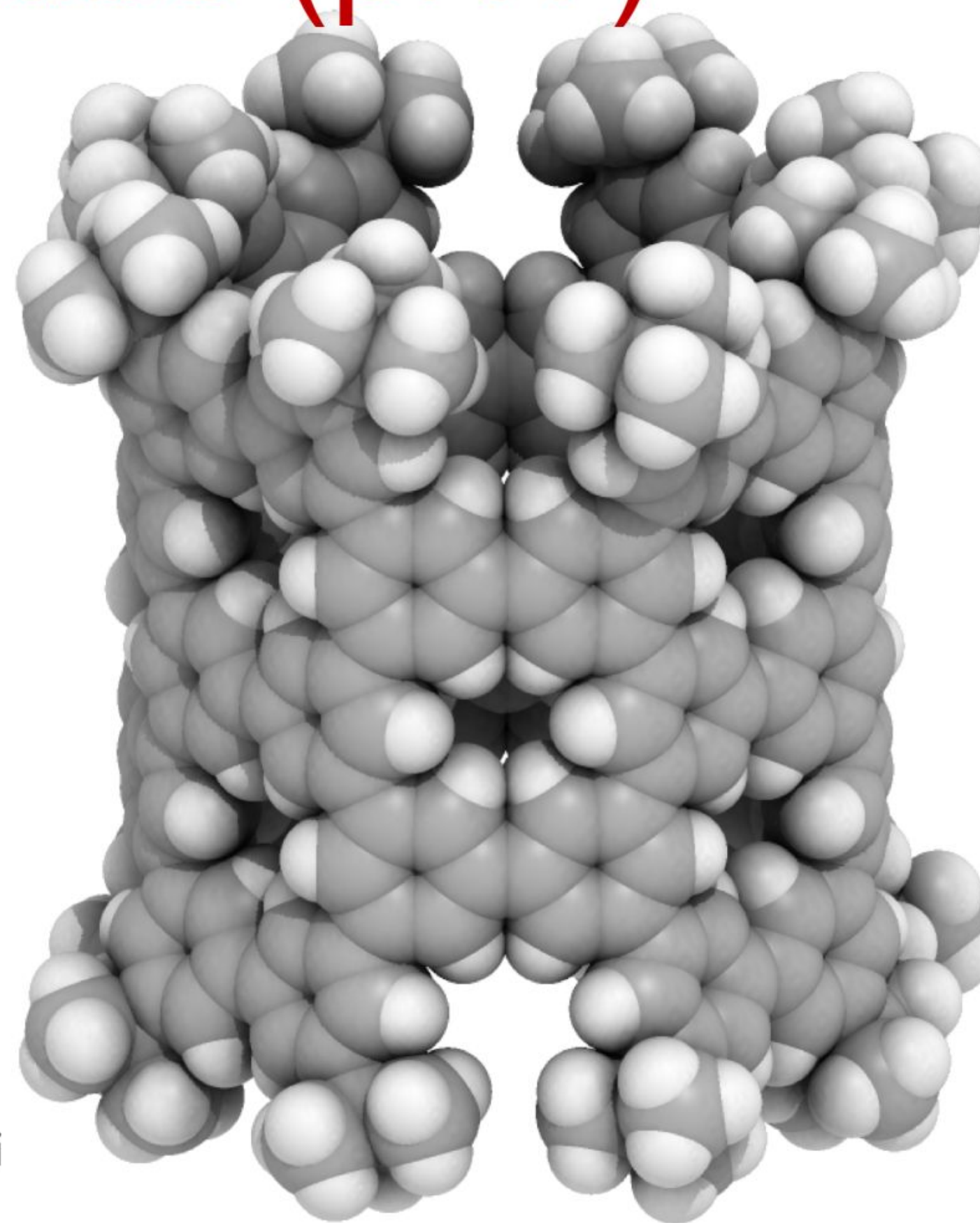
Power of chemistry - Anything can be made

Phenine nanotube (pNT)

Precision is at another level



— Yamamoto coupling
— Suzuki-Miyaura coupling
— Bäurle/Yamago/Isobe coupling



They are addressing sustainability challenges

CLEAN AIR WITH PHOTOCATALYSIS

Akira Fujishima

Former President of Tokyo University of Science
Director, Photocatalysis International Research Center, TUS

Clean water for all

We developed environmentally friendly water positive nanoscale materials for affordable, sustainable and rapid removal of arsenic from drinking water.

There are over 1700 community installations across the country, serving 1.3 million people with arsenic and iron-free water every day.

Implementation - From 25 KLD to 2 MLD



Large water supply schemes
Capacity: above 1 MLD

5 schemes in use across India



Retrofitted Water Purification Plant
Capacity: 0.1-1 MLD

Over 180 units in use across India

**Can Water – Mother of all Solvents – Be a
New Medium for Chemical Synthesis?**

Science

**A scale of 10
00**

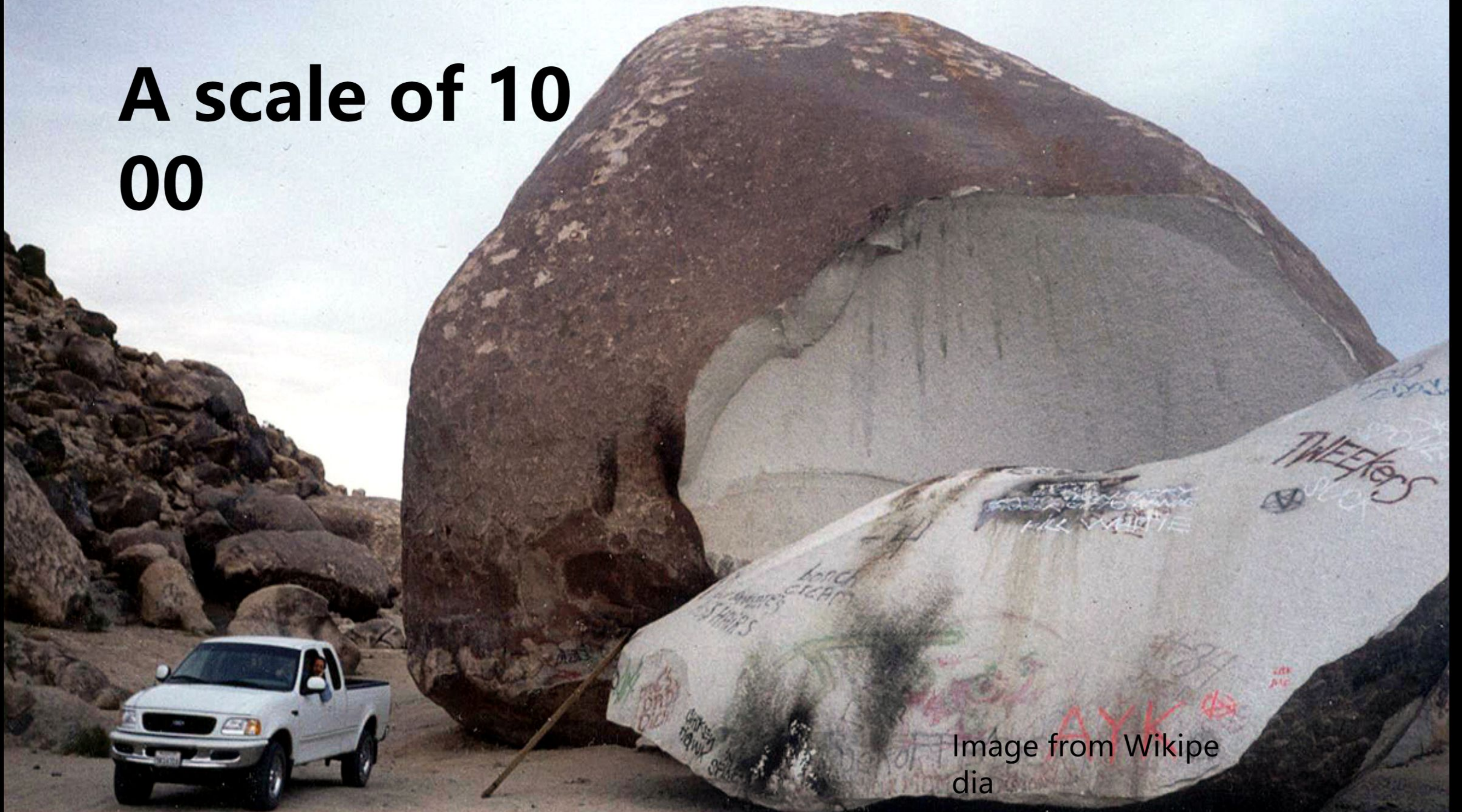


Image from Wikiped
ia



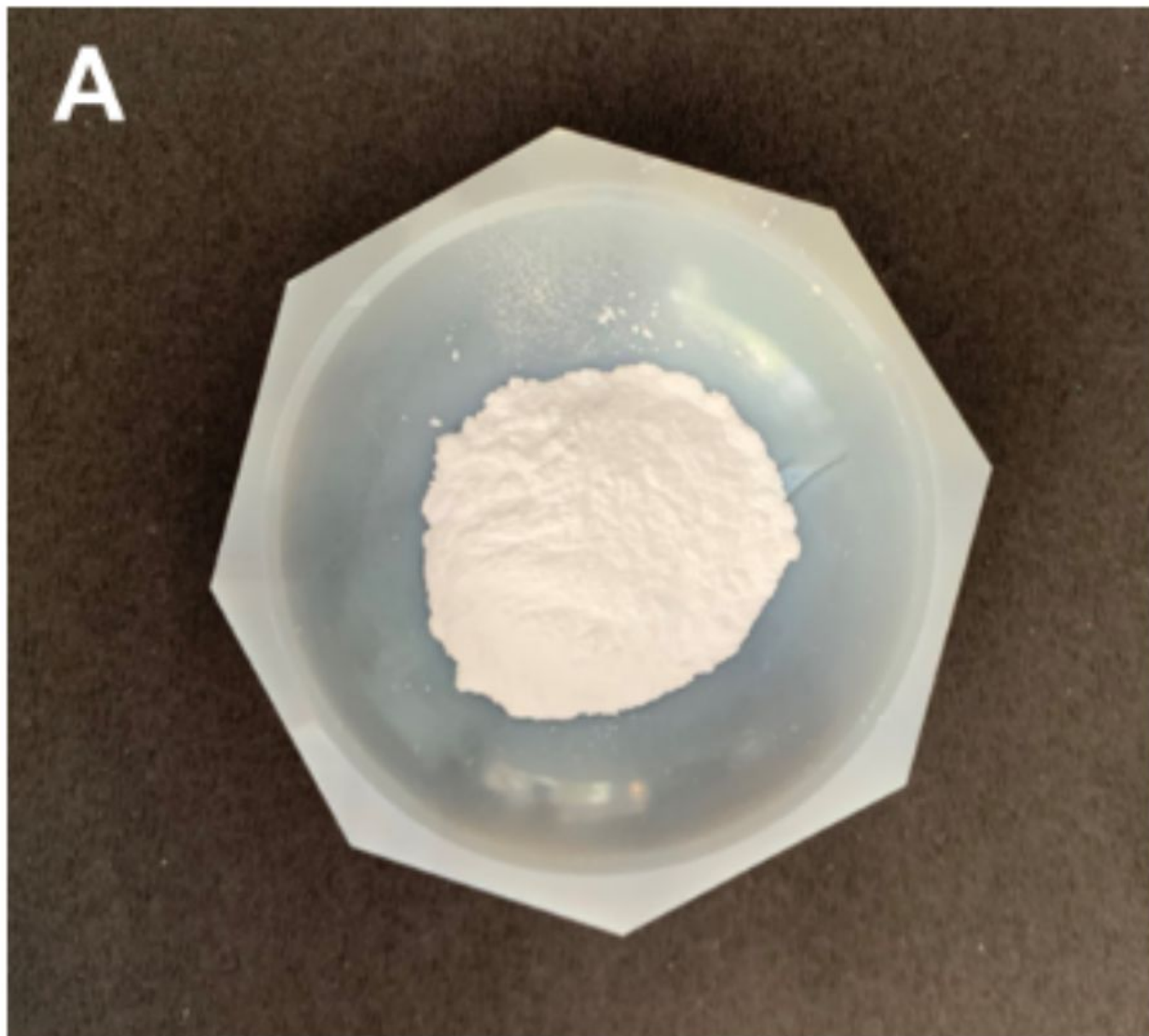
Thanks to ChatG
PT

Sand, the ubiquitous material

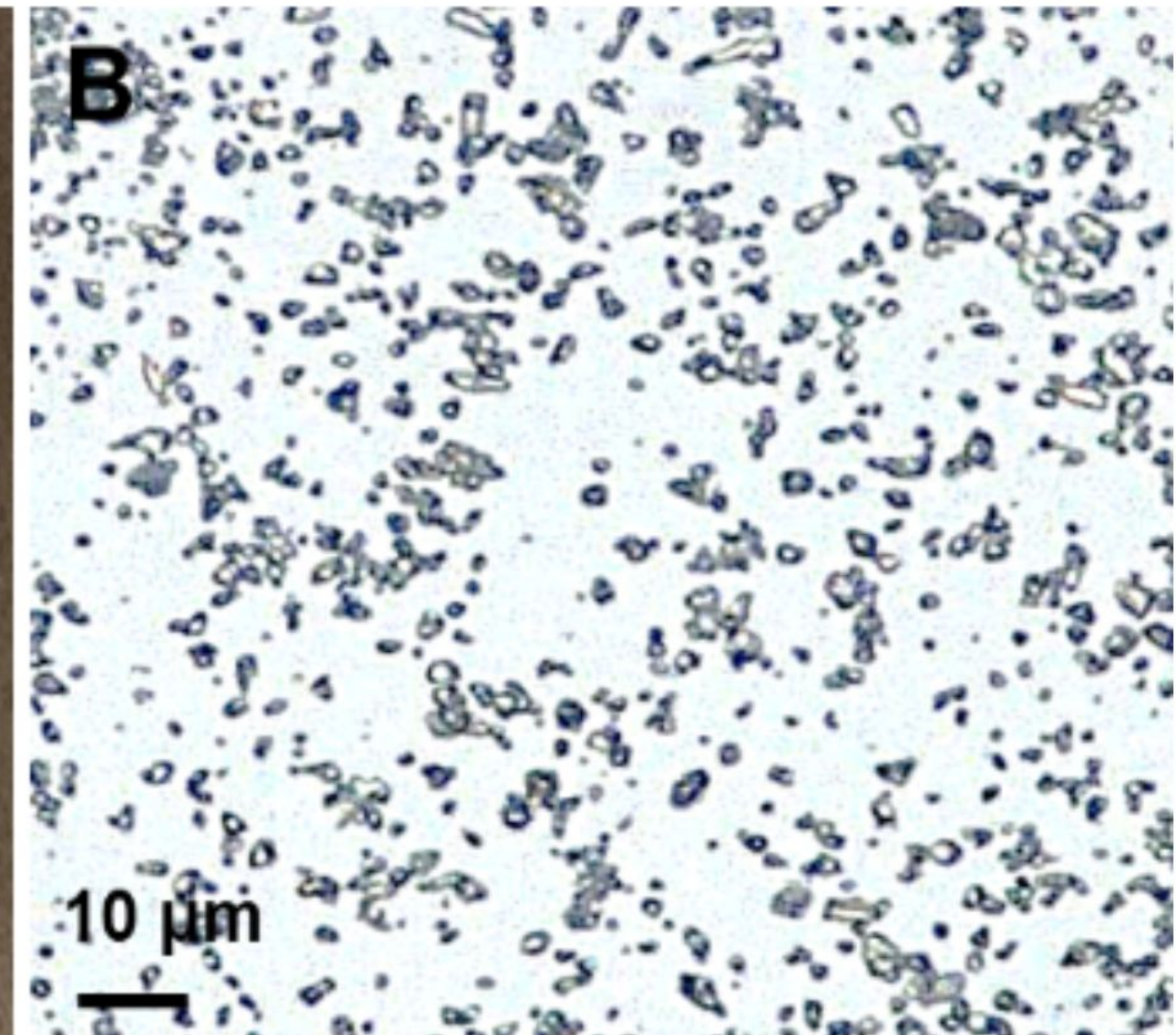


Images from Wikipedia



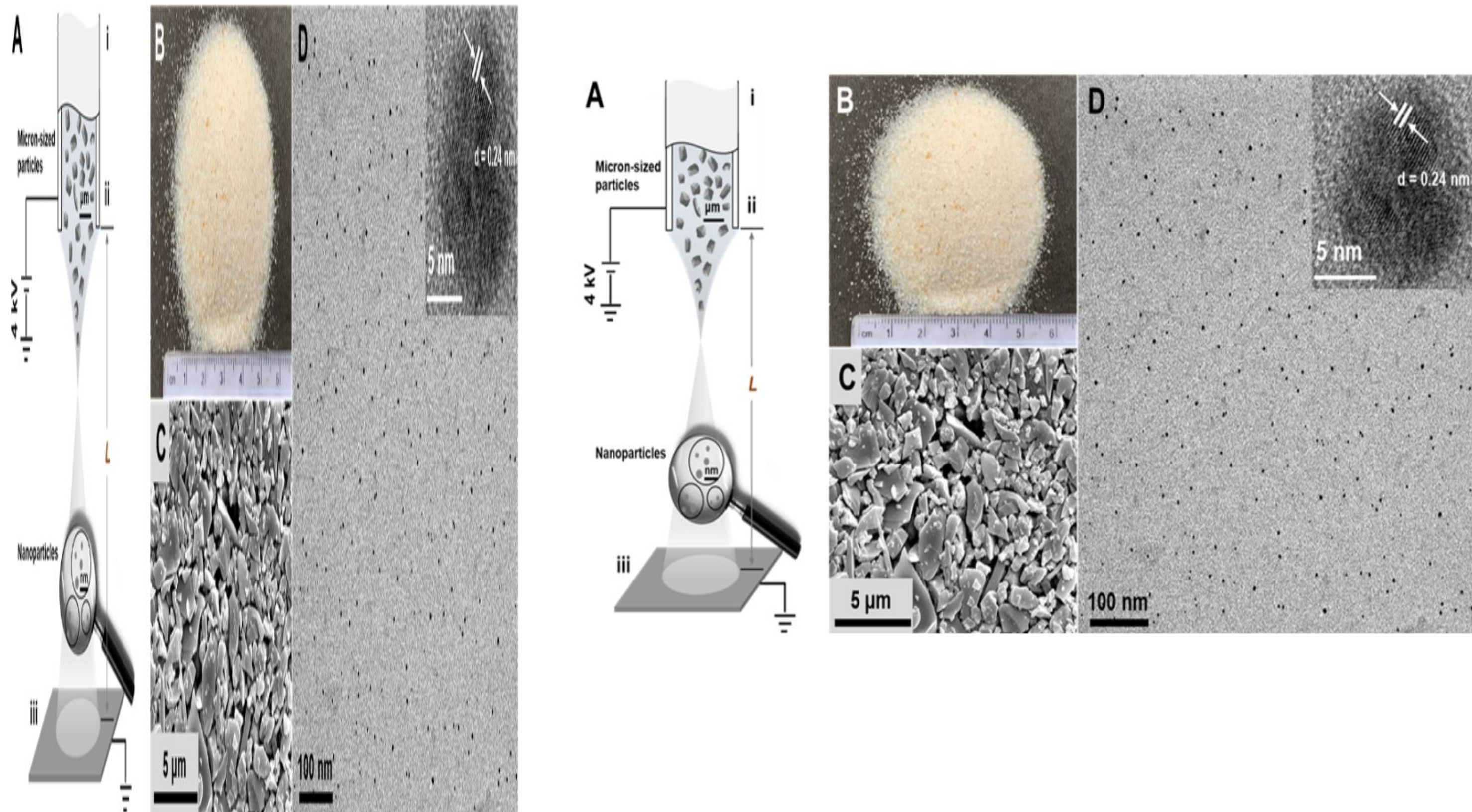


Ground silica



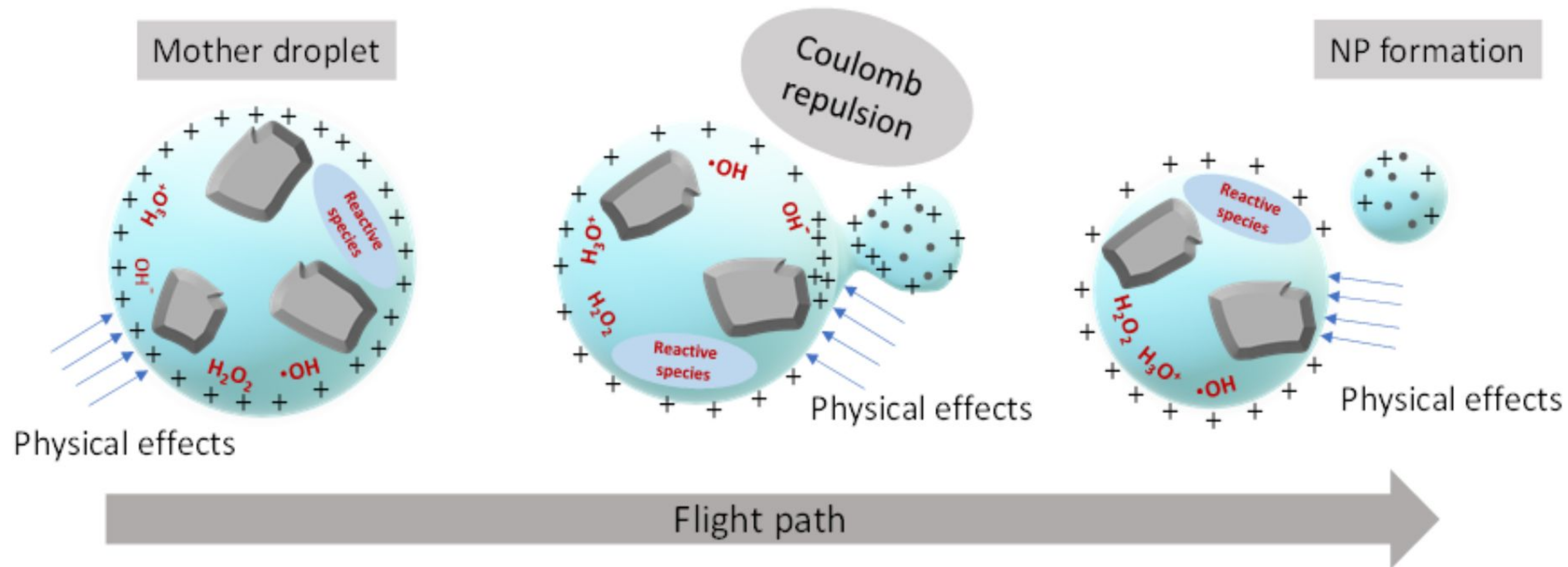
Optical image of silica

Weathering of minerals in microdroplets



**Ruby, fused alumi
na**

Mechanism of nanoparticle formation



Salts bring down the potential

Disintegration of quartz particles suspended in NaCl solution. (A to D) Transmission electron microscopic (TEM) images of quartz after electrospray of quartz suspension in varying concentration of NaCl (5 ppm, 0.5 ppm, 0.1 ppm and 0.05 ppm respectively) at an applied potential of 2.0 kV, with a tip-to-substrate distance of 1.5 cm. High-resolution TEM image of a particle shown in the inset. The plane shown is (110), where d is lattice spacing.

Disintegration of quartz particles in charged water microdroplets containing acid (HCl) and salt solutions at ppm levels. (A-F) Transmission electron microscopic (TEM) images showing morphological variations of quartz particles (suspended in different alkali metal chloride solutions) after electrospray at an applied potential of 2.0 kV, with a tip-to-substrate distance of 1.5 cm and salt concentration of 0.1 ppm. (G-J) TEM images of quartz particles suspended in different sodium halide solutions (NaF, NaCl, NaBr, and NaI, respectively) following electrospray under identical conditions (2.0 kV, 1.5 cm, 0.1 ppm). Distinct morphological features highlight the influence of ionic composition on disintegration efficiency.

Grand unification of synthesis

Radicals, ions

Transient species

S

S

Electric field

E

Field
s

Pressure fluctuations

ns

M

MV cm
-1

MP
a

50-90 MV c
m-1





ChatGP
T

Vision

Make soil using processed wastewater and make deserts bloom.

Functional nanomaterials!

No solvents

Ambient conditions

Sustainable





Acknowledgements

Collaborators, DST, ANRF, IIT Madras, Institute of Eminence