Cu element

Chemistry Of Elements(chem-e4130)

Seminar Presentation

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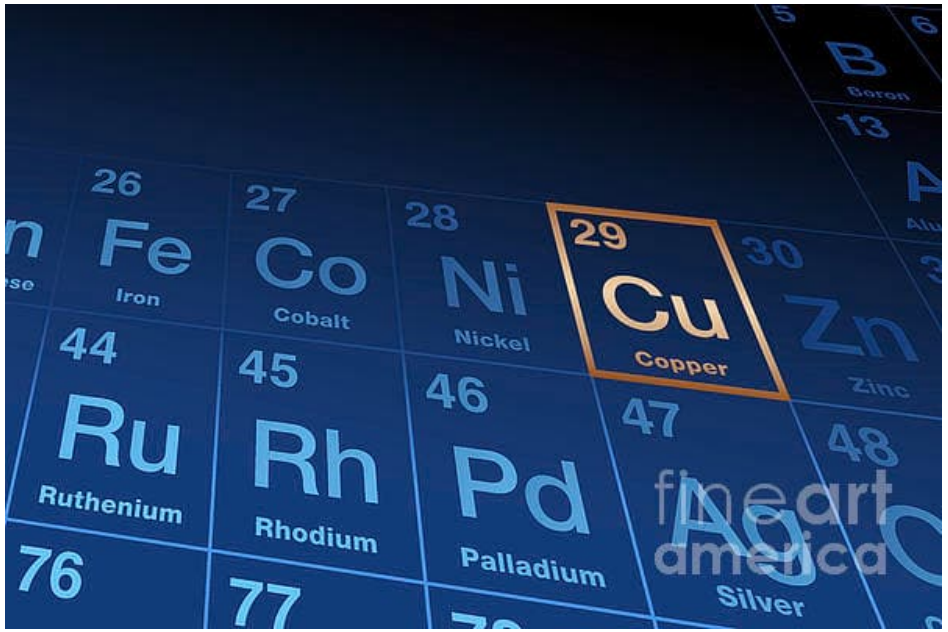
Outline

Element

Chemistry

Compounds

Specific Applications



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Discovery

Known as oldest metal

Discovered at 8000 BC by early Mesopotamians

Primarily Cu tools and decorative items were used

Copper beads have been excavated in northern Iraq about ten thousand years old which made from native copper

Copper was widely used in the ancient world as bronze to make cutlery, coins, tools.

In China it was used for bells.

Origin of Name

Old English name 'coper' derived from the Latin name **‘Cyprium aes’**, meaning a ‘metal from Cyprus’.

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Abundancy

25th most abundant element in the earth crust

Copper is found in the earth crust as a metal and in various mineral like cuprite-Cu_2O, chalcopyrite-$CuFeS_2$ and malachite -$Cu_2CO_3(OH)_2$

Has two stable isotopes, ^{63}Cu and ^{65}Cu, with relative abundances of 69.15 % and 30.85 %

Abandoned copper working on the Green Line near the Xeros valley

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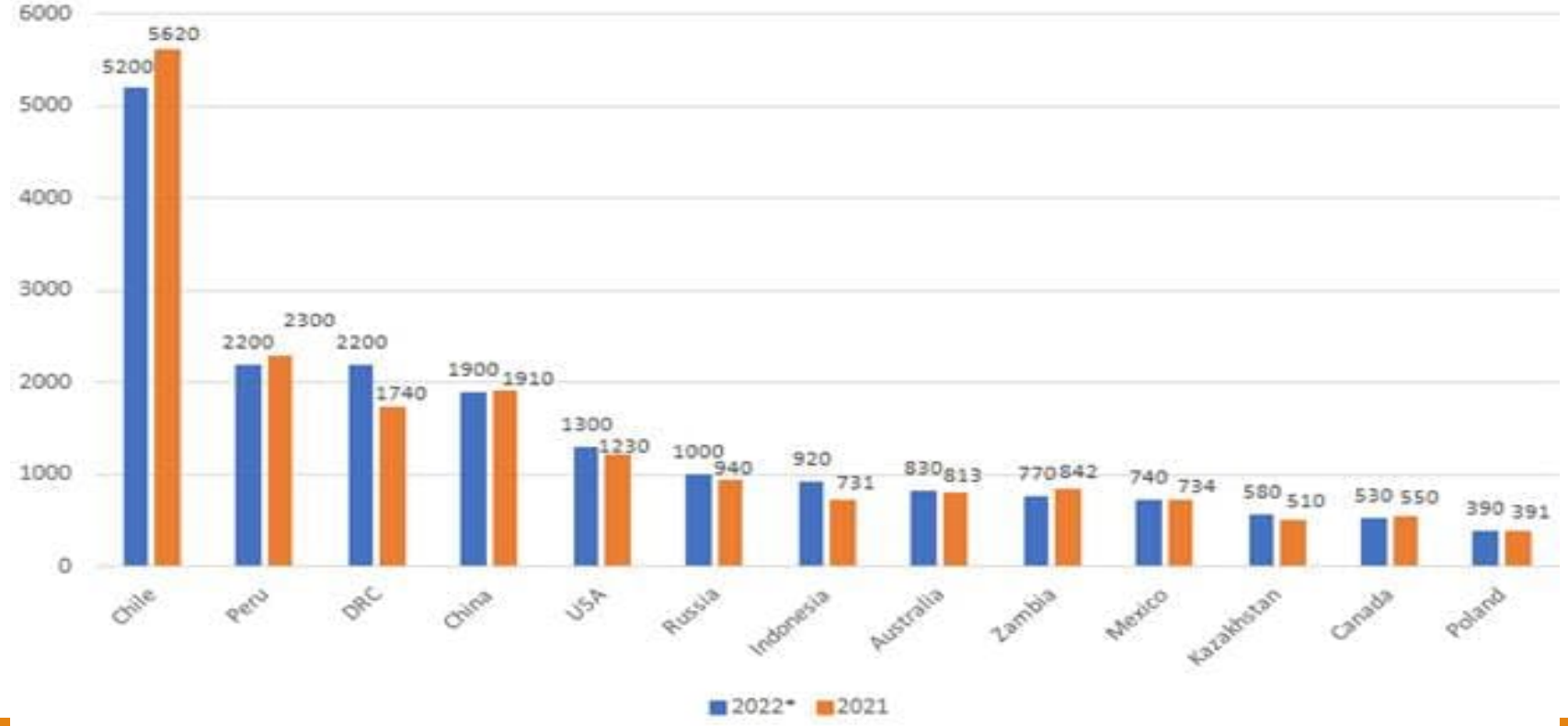
World Production

US geological survey data shows copper production reached 22 million metric tons(MT) in 2022.

Chile was the top producer with an estimated production of 5,200,000 Tons.



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World Production

Cu is mined using open pit or underground mining.

90% is from open pit mining

It involves digging into the earth's crust in measured steps to remove ores situated close to the surface.

When the depth of the ore makes open-pit mining impractical, underground mining is used.

machinery or explosives may separate the ore.

Open pit mining

Underground mining

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Special Features

Natural antibacterial agent

- *Electrically charged ion particles*
- *Brass door handles*
- *Use in ship hulls*

Essential element for human nutrition

- *Blood cells formation*

statue of Liberty

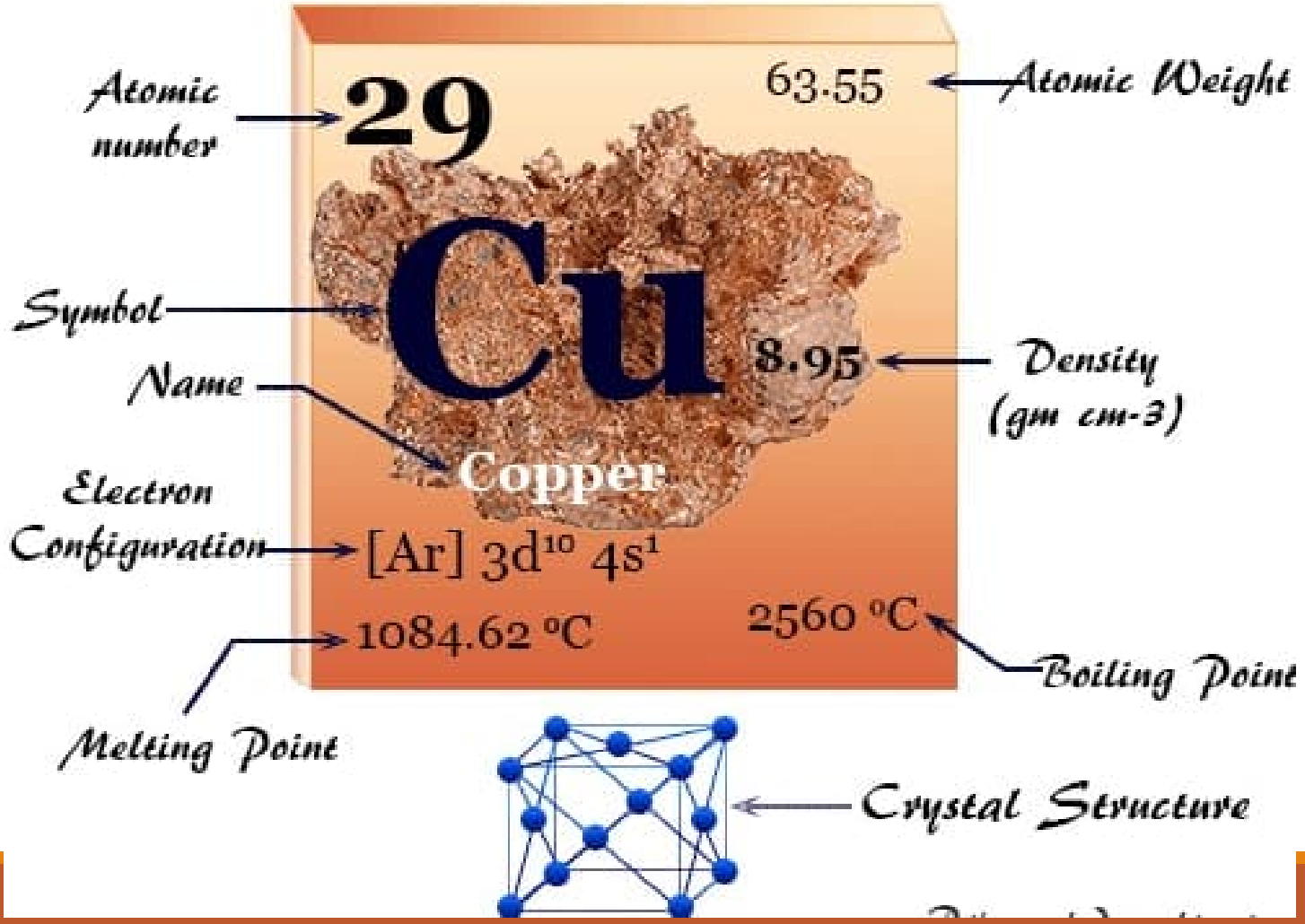
- *Made out of Copper*
- *Red brown copper skin in 1886*

every industry

- *Excellent conductor of Electricity and Heat*

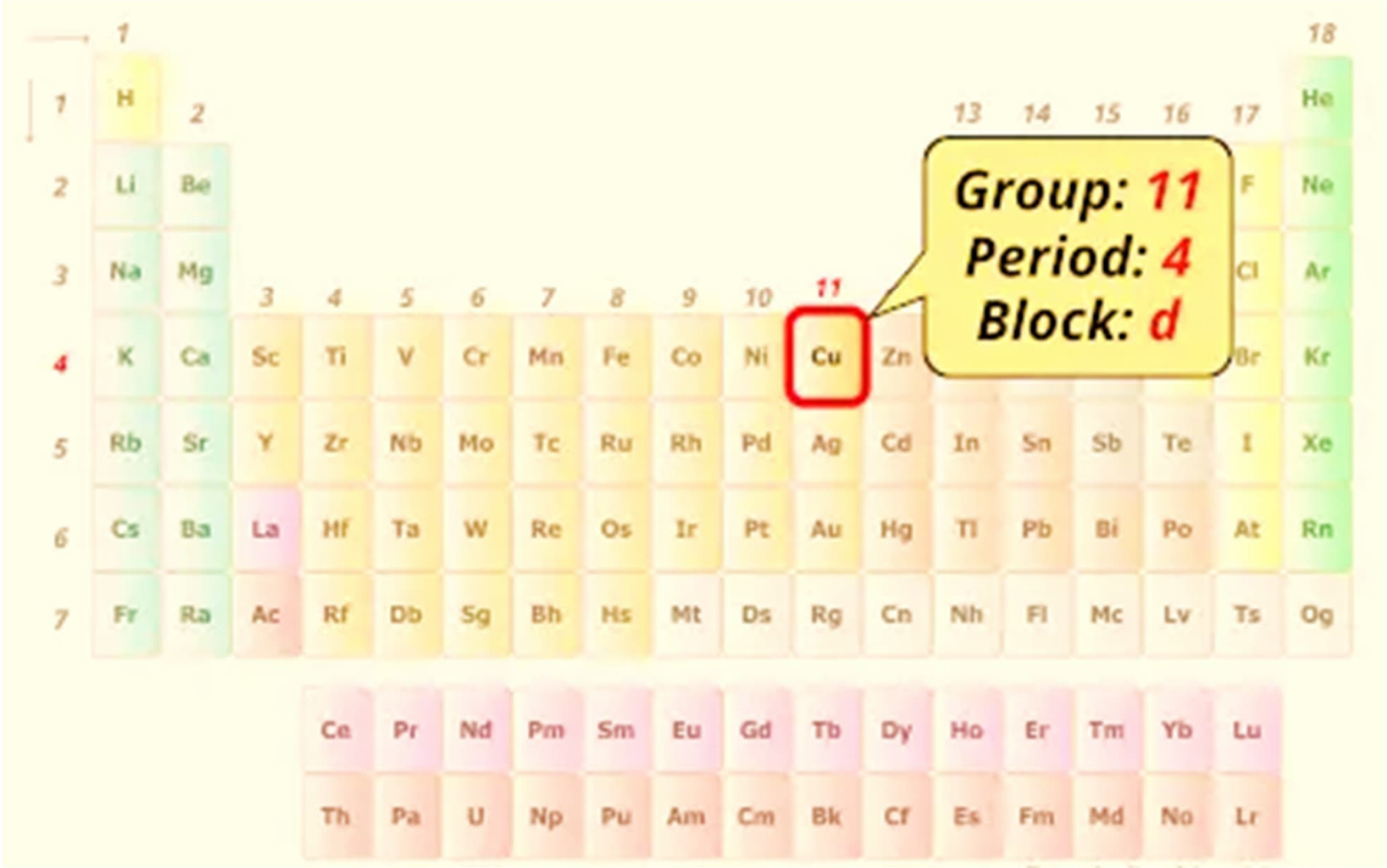
Liberty Statue

Chemistry


Atomic number
29
63.55
Atomic Weight
Cu
Symbol
Name
Copper
8.95
Density (gm cm-3)
Electron Configuration
[Ar] 3d10 4s1
1084.62 °C
2560 °C
Boiling Point
Melting Point
Crystal Structure

- Transition metal
- Isotopes: ^{63}Cu ,^{65}Cu
- State at 20°C –Solid
- Appearance – Reddish gold metal
- Diamagnetic
- High electric and thermal conductivity

Position in Periodic Table



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- Electron configuration- $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \ 3d^{10}\ 4s^1$
- Oxidation States

  Existing oxidation states- +3, +2, +1

  Cu2+ and Cu+1 oxidation states are most stable

  Cu1+ - $[Ar]3d^{10}\ \ 4s^0$

  Cu2+ - $[Ar]3d^9\ \ 4s^0$

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Metal and ionic sizes

Cu metal – 1.22 Å

Ion	Coordination type	Radius(Å)
Cu(I)	4-coordinate, tetrahedral	0.74
Cu(II)	4-coordinate, tetrahedral	0.71
Cu(II)	4-coordinat, square-planar	0.71
Cu(I)	6-coordinate, octahedral	0.91
Cu(II)	6-coordinate, octahedral	0.87
Cu(III)	6-coordinate, octahedral	0.68

Reactivity

- One of the least reactive metal
- The only metal apart from precious metals that do not react with water or dilute acids
- Reacts very slowly with oxygen
- Reactivity of cu:
    1. Patination
    2. Etching

Patination

$$4Cu + O_2 \rightarrow 2Cu_2O$$

$$2Cu_2O + O_2 \rightarrow 4CuO$$

$$Cu + S \rightarrow CuS$$

$$2CuO + CO_2 + H_2O \rightarrow Cu_2CO_3(OH)_2$$

$$3CuO + 2CO_2 + H_2O \rightarrow Cu_3(CO_3)_2(OH)_2$$

$$4CuO + SO_3 + 3H_2O \rightarrow Cu_4SO_4(OH)_6$$

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Etching

$$FeCl_3 + Cu \rightarrow FeCl_2 + CuCl$$

$$FeCl_3 + CuCl \rightarrow FeCl_2 + CuCl_2$$

$$CuCl_2 + Cu \rightarrow 2CuCl$$

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Compounds

Copper Sulfate (CuSO4):

- Properties:
  - Blue crystalline solid
  - Soluble in water
  - It can undergo dehydration to form anhydrous copper sulfate.
- Applications:
  - fungicide in agriculture to control plant diseases.
  - Herbicide to control unwanted plant growth.
  - Used in electroplating and as a catalyst in organic synthesis.

Copper Oxide (CuO):

- Properties:
  - Black solid
  - Conducts electricity.
  - Used as a catalyst.
- Applications:
  - Semiconductor material for electronics and solar cells.
  - Catalyst in various chemical reactions, like the synthesis of methanol.
  - Pigment in ceramics and glass.

Copper Nitrate ($Cu(NO_3)_2$):

- Properties:
  - Blue-green crystalline solid
  - Soluble in water.
- Applications:
  - Fireworks
  - Pyrotechnics
  - Metal Finishing

Copper Chloride (CuCl2):

- Properties:
  - Green to blue-green crystalline solid
  - Soluble in water.
- Applications:
  - Etching: Used in the etching of printed circuit boards.
  - Chemical Synthesis: Acts as a catalyst in chemical reactions.
  - Textiles: Used as a mordant in dyeing.

Copper Acetate ($Cu(CH_3COO)_2$):

- Properties:
  - Green crystalline solid
  - soluble in water.
- Applications:
  - Organic Synthesis: Used as a catalyst in organic reactions.
  - Rayon Production: Involved in the manufacture of rayon fibers.
  - Pigments: Used in the preparation of green pigments for paints and ceramics.

Copper Carbonate (CuCO3):

- Properties:
  - Green crystalline solid
  - Insoluble in water.
- Applications:
  - Pigments: Used in the creation of green colors in paints and ceramics.
  - Agriculture: Applied as a fungicide and in feed supplements for livestock.

Specific Applications

Bio-inspired hydrophobicity promotes CO2 reduction on a Cu surface

electrocatalytic reduction of CO2 → **alcohol and hydrocarbon fuels.**

hydrophobic electrode attained a 56% Faradaic efficiency for ethylene and 17% for ethanol production at neutral pH, compared to 9% and 4% on a hydrophilic, wettable equivalent.

Cu is the only material able to catalyze the substantial formation of multicarbon products, C2/C3.

Superhydrophobic surface is generated by 1-octadecanethiol treatment of hierarchically structured Cu dendrites, inspired by the structure of gas-trapping cuticles on subaquatic spiders.

Increase the concentration of CO2 at the electrode–solution interface and

consequently increase CO2 reduction selectivity.

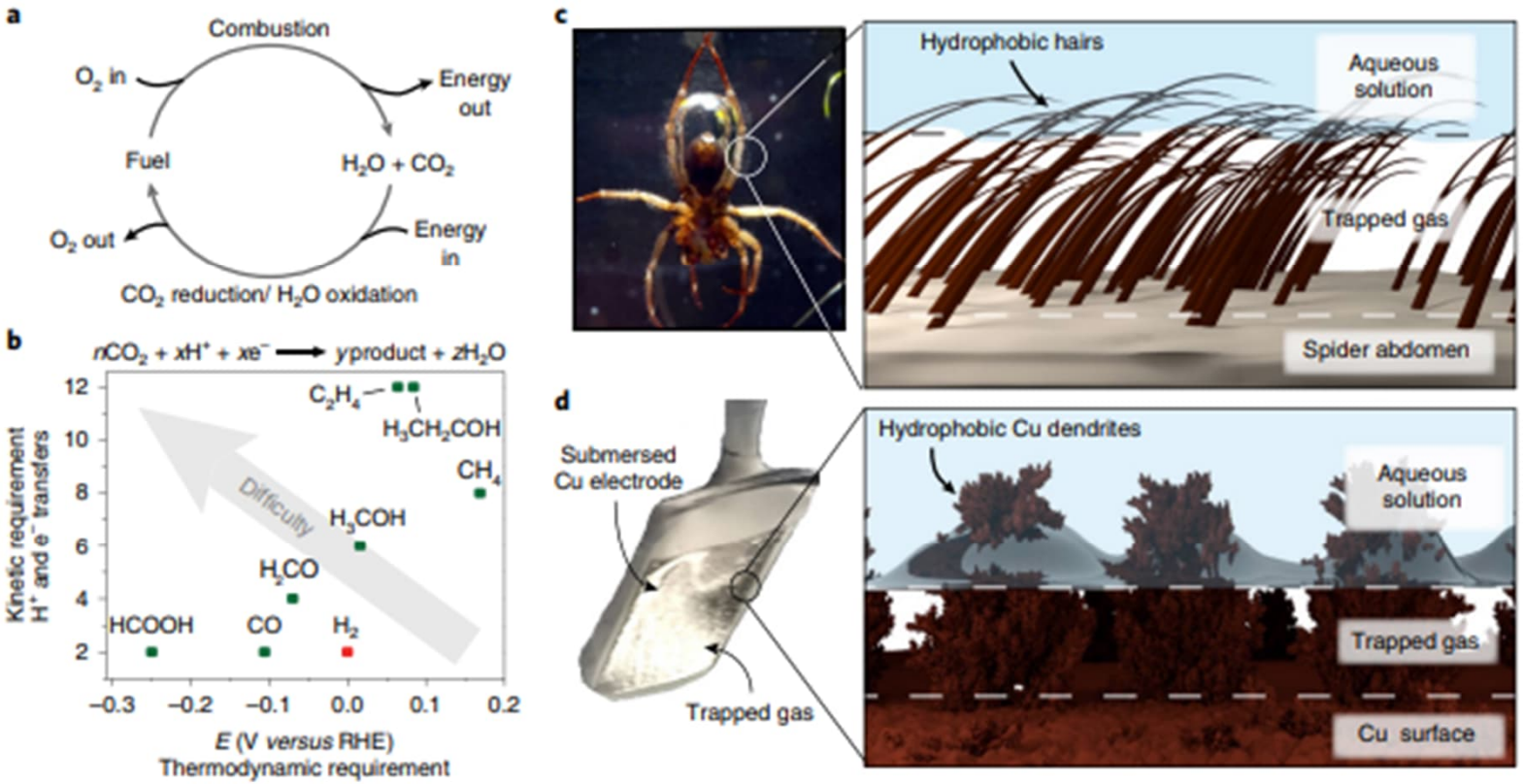
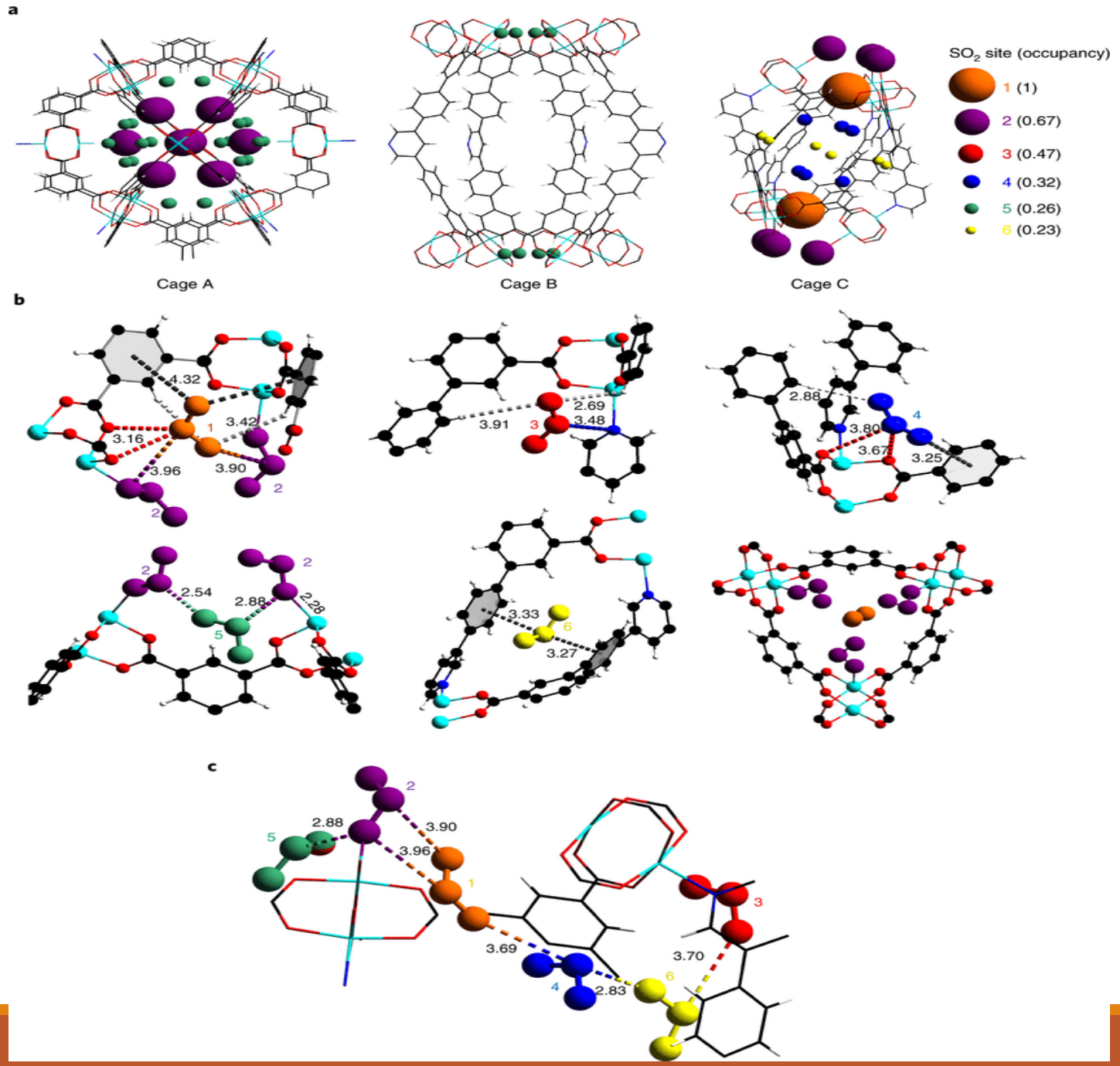


Fig. 1 | CO_2 reduction as a source of sustainable fuel and an introduction to the plastron effect. a, The generation of renewable fuel through CO_2 reduction and H_2O oxidation. **b**, The kinetic versus thermodynamic requirement of various CO_2 reduction reactions[3]. The plotted values are based on the reaction equation given above the graph, made stoichiometric according to the product composition. **c**,**d**, The plastron effect: the use of a hydrophobic surface to trap a layer of gas between the solution–solid interface. This is illustrated on a diving bell spider for subaquatic breathing in **c** and on a hydrophobic dendritic Cu surface for aqueous CO_2 reduction in **d**. The photo of the diving bell spider is adapted from Seymour and Hetz[42] with permission from The Company of Biologists.

Adsorption and Separation of SO2

- **MFM 170** is the robust material with open Cu(II) sites.
- At 298 K, 1.0 bar MFM 170 uptake SO2 highly(17.5 mmolg-1) and it is fully reversible at ambient temperature.
-High selectivity of MFM 170 towards SO2 has been detected by single crystal X-ray diffraction and FTIR technology.



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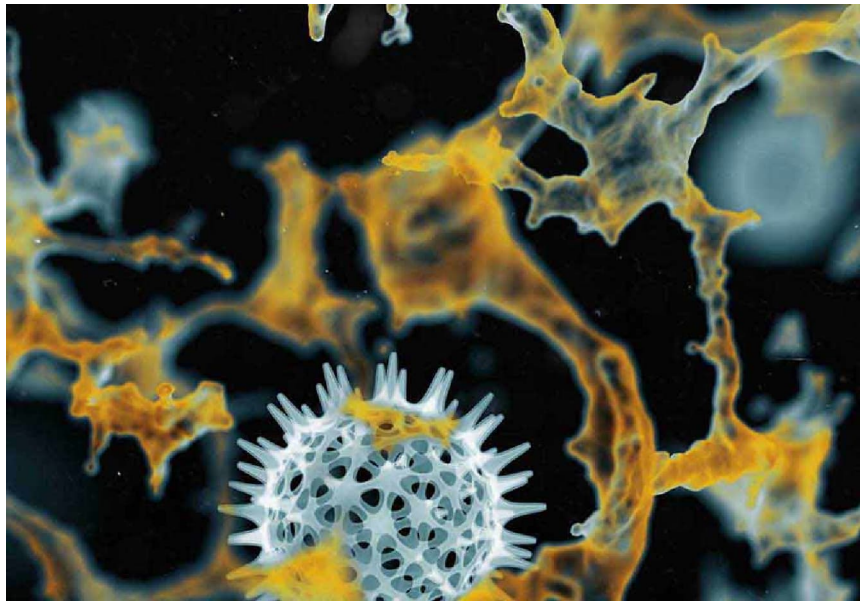
Cu/Co-hybrid MOF nanostructures

High antibacterial, antifungal activity

- *Staphylococcus aureus*
- *Streptococcus pyogenes*
- *Fusarium oxysporum*
- *Candida albicans*
- *Aspergillus fumigatus*

cytotoxicity activity

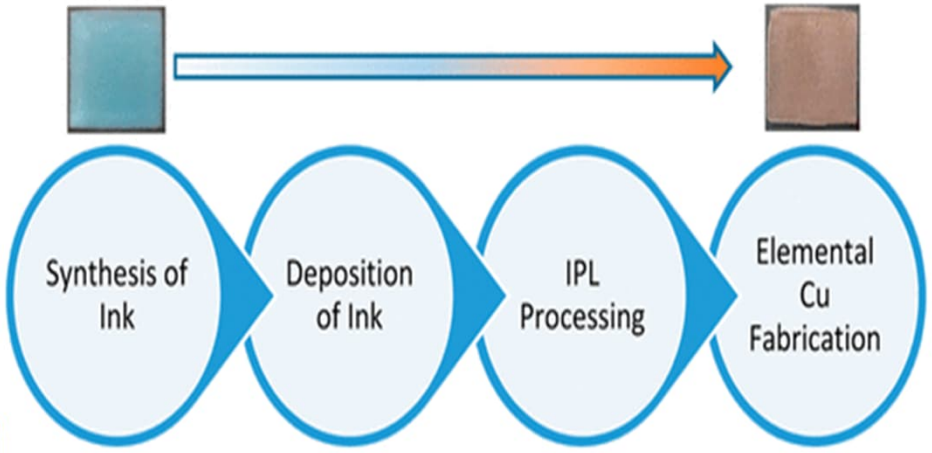
Treatment for MCF-7 breast cancer cells



Fabrication of Elemental Copper by Intense Pulsed Light Processing of a Copper Nitrate Hydroxide Ink

Copper precursor ink from $Cu_2(OH)_3NO_3$

- aqueously synthesized under ambient conditions with copper nitrate and potassium hydroxide reagents.
- Films were deposited by screen-printing and subsequently processed with intense pulsed light.
- The direct formation of Cu from the $Cu_2(OH)_3NO_3$ requires a reducing agent; therefore, fructose and glucose were added to the inks.
- the thermal decomposition of the sugars led to direct conversion of the films into elemental copper.
- Used in printed electronic devices and renewable energy technologies



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Bimetallic Copper–Iron Oxide Nanoparticle-Coated Leathers for Lighting Applications

Bimetallic Copper-Iron Oxide nanoparticles using simple precipitation method followed by Calcination at 500 C
Spherical shape with the size of 54 nm
Properties: Electrical Conductivity
Ferromagnetic Properties

Coating them to the leather surface to make **bifunctional leather** : Electrically conductive
Magnetically active

Bifunctional Leather use for operating touch screen devices and for magnetic control switch appliances

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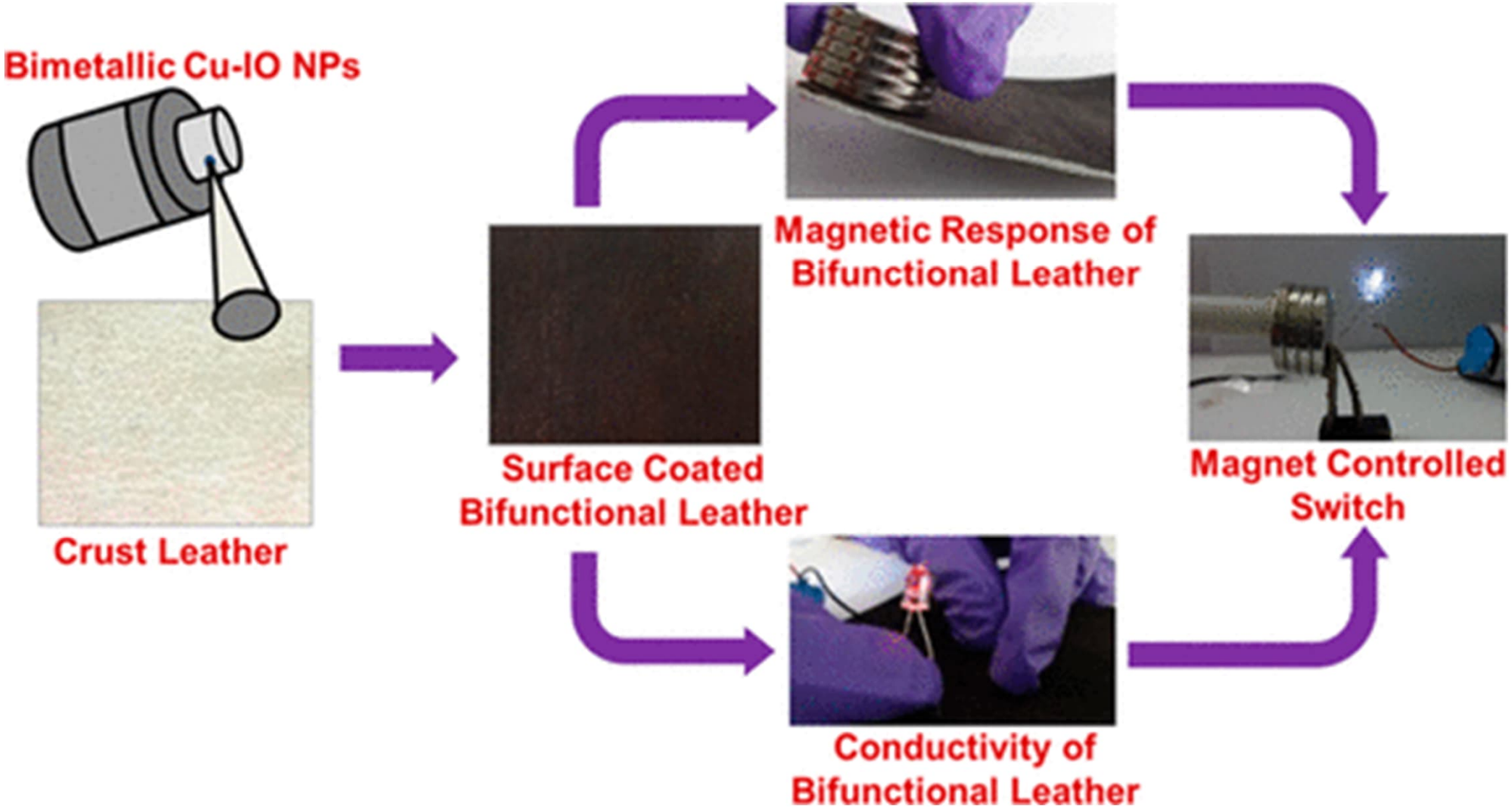

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Thank You !

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