

# Protective equipment with new material(s)

- Is this possible?

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# Agenda

- Protection against...?
- New materials technology
  - Graphene
  - Metal oxide frameworks (MOFs)
  - Ceramics
  - Non-Newtonian liquids
  - Auxetic solids
  - Non-linear optical materials
  - Processes & manufacturing
- Summary & conclusions



Ballistic protection



Chem-suit model 90

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# Protection against...?

Historical

- Lead bullets and shrapnel (upper body & head)

Modern

- Blast (IED & mines)
- Armour piercing bullets
- Thermobaric weapons
- Flash, flame
- Toxic agents

Whole body

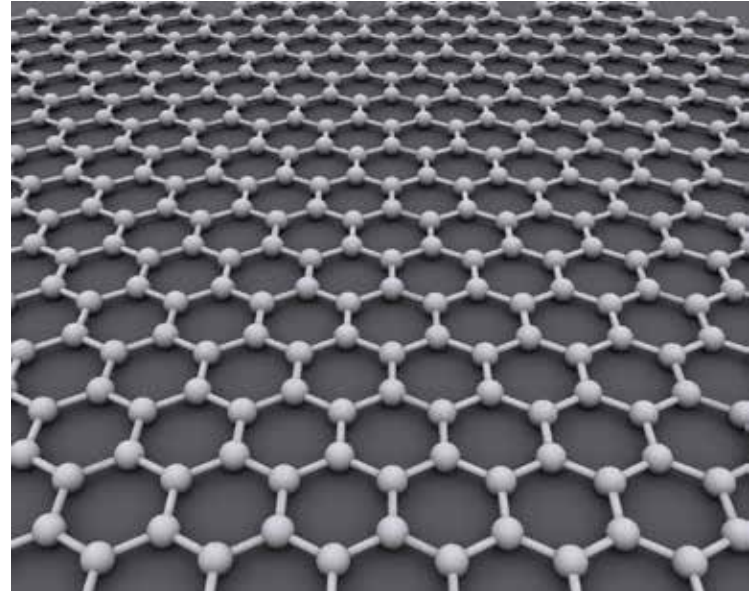
Future

- Laser
- Microwave
- ...



# Graphene – basic properties

- Unique combination of extreme properties
  - Tensile strength
  - Elasticity
  - Fracture toughness
  - Fracture strain
  - High sound velocity
  - Impermeable to everything
  - ....
  - In the laboratory...



Wikipedia CC

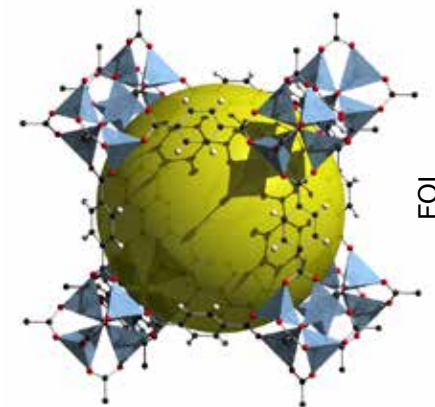
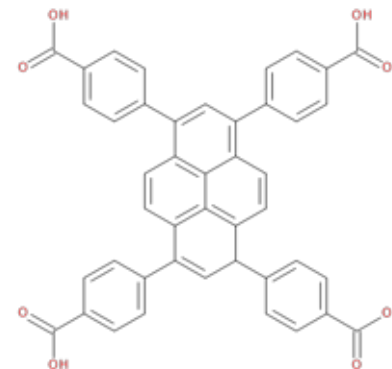
# Graphene ballistic protection?

- NOT as single material, but...
  - In a polymer composite
  - In a fibre-reinforced polymer composite
  - In a ceramic matrix
  - In a graphene reinforced fibre
- Will require development & testing



# Metal-Oxide Frameworks (MOFs)

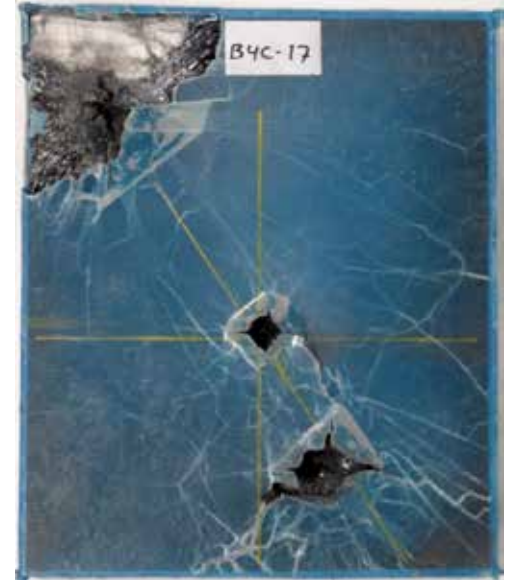
- Toxic agents are a credible threat
- Activated carbon has been used for decades
- It is effective and cheap, but heavy
- It is sensitive to humidity
- MOFs have extreme surface area
- MOFs can be designed to trap particular molecules
- MOFs can neutralise toxic agents
- In the laboratory...



Upper MOF NU1000  
Lower MOF 5

# Ceramics are effective, but...

- Weight & cost are problems
  - Boron carbide is lightweight but expensive
  - Aluminium oxide is affordable but heavy
- Improved processing can reduce cost
- Ceramics with lower density, or improved toughness are possible
- Graphene-toughened ceramics are possible

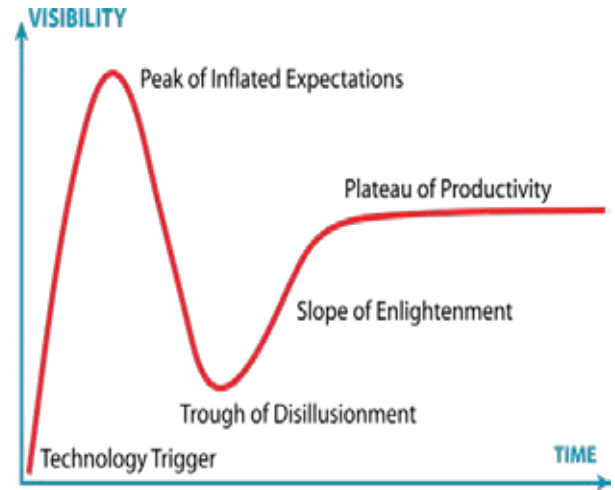


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Ceramball multihit test

# Other new materials & important factors

- Non-Newtonian liquids harden when hit
- Auxetic solids absorb impact energy
- Non-linear optical materials block high power lasers
- New manufacturing processes are available
- Computational materials design is becoming easier
- Synthetic biology is developing
- .....



The Gartner curve – avoid if possible!





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