Graphene: A new material for wound healing

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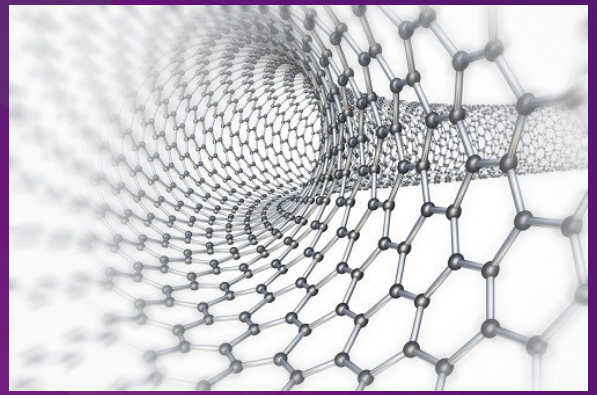
What is Graphene and some of its derivatives ?

- Graphene could exist as monolayers, multi-layers, carbon nanotubes, oxides, reduced oxides, and polystyrene



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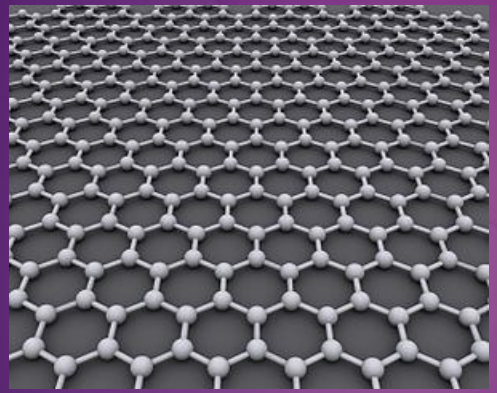

It has amazing properties (incredibly thin but still incredibly strong, good heat and electrical conductivity, almost entirely transparent yet very dense.) and Andre Geim and Sir Kostantin Novoselov won Nobel Prize in 2010 for their groundbreaking experiments regarding the two-dimensional material graphene.

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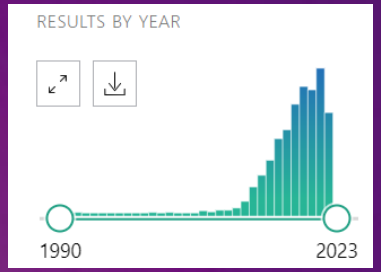
Graphene's properties:- anti-friction, lightweight, electrically conductive, thermally conductive, st
transparent, tear resistant, impermeable, flexible and thin.

Potential biological uses of Graphene



- tissue engineering (1,452 results - pubmed)
- skin/muscle/nerve/bone/cartilage repair
- sensors for monitoring diabetic foot and venous leg ulcers (Salvo 2017)
- multifunctional sutures (Houshyar 2021)
- light-triggered antibacterial activity as a form of hybrid hydrogel (Li 2021; Rosselle 2020).

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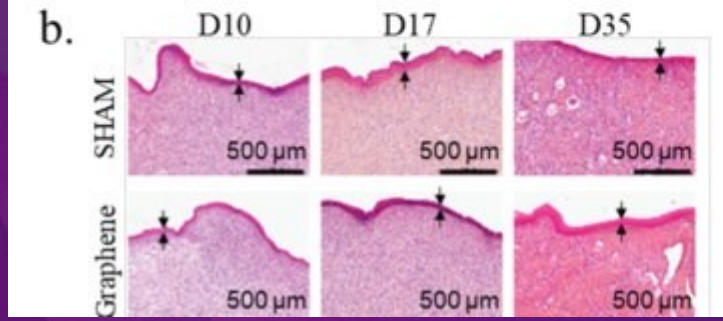
New dressing materials with graphene



- Wound healing in eczema,
- bed sores or
- burning accidents

Monolayer graphene-on-polymer dressings promote healing and stabilize skin temperature on acute and chronic wound models (2021) Marion Le Gall, Vincent Serantoni, Hervé Louche, Franck Jourdan, Dominique Sigaudo-Roussel, Christelle Bonod, Sandra Ferraro, Riadh Othmen, Antoine Bourrier, Latifa Dahri-Correia, Charlotte Hurot, Luc Téot, Vincent Bouchiat, Alain Lacampagne **doi:** https://doi.org/10.1101/2021.05.16.444337

These patients have a high risk of bacterial infection, and some graphene materials have shown to provide good therapeutic efficacy in the improvement of wound healing with new dressing materials

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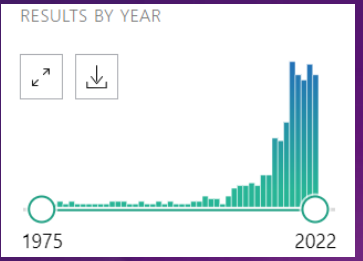
The mechanism of wound healing (pubmed)

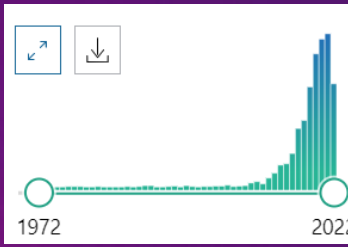


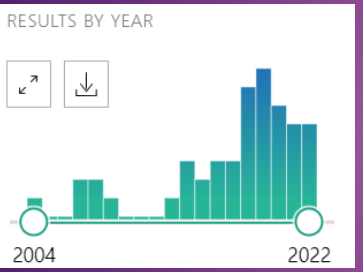
- 2. anti-inflammatory effect

348 results

- 1. anti-bacterial properties,

1,692 results



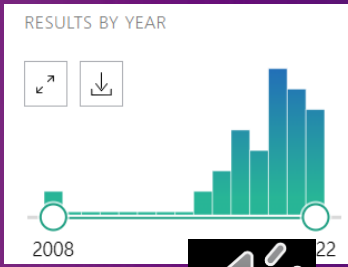


- 3. angiogenic properties.

44 results

23 results

- 4. Immunomodulatory properties



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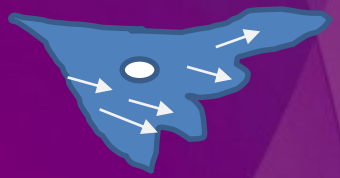
Graphene's properties which helps with would healing:

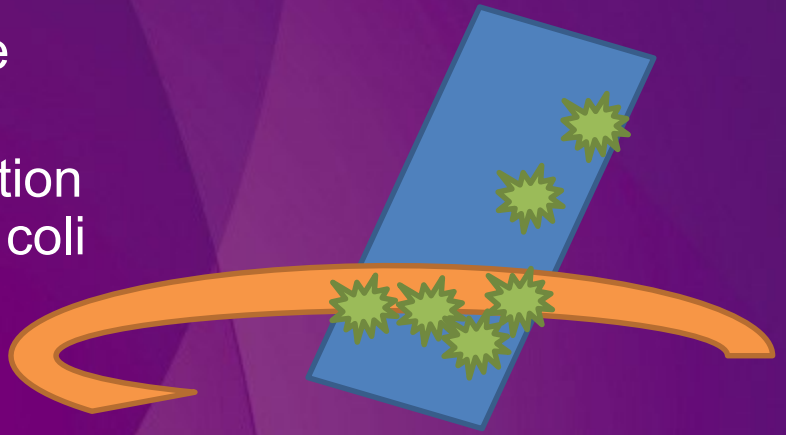
- lack of cytotoxicity,
- compatibility with biological material in terms of adhesiveness,
- lack of inhibition of healthy cell migration.



http://beeasy.biz/?page_id=469

The Reason for anti-bacterial property

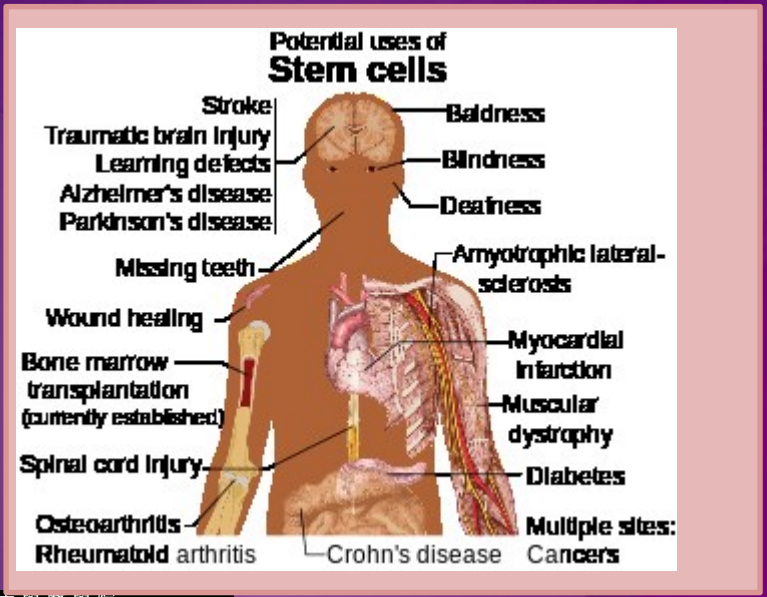
- dehydrating properties or the ability of some functional groups to generate free radicals that kill pathogenic bacteria
- graphene nanosheets induced degradation in the outer and inner membranes of E. coli and reduced their viability (Tu 2013) by inserting/cutting through the cell membranes of *E. coli* and vigorously extract large amounts of phospholipids from the membranes.



Tu et al 2013

Demonstration of biocompatibility

- By examination of the adhesion of fibroblasts cell lines and the morphology of their filopodia (or the feet)



Hydrophobic and aromatic groups on proteins and small molecules can adsorb onto graphene via hydrophobic and π-π interactions with the carbon lattice, and in the case of oxidized forms of graphene materials, (GO and rGO) interactions can also occur through hydrogen bonding

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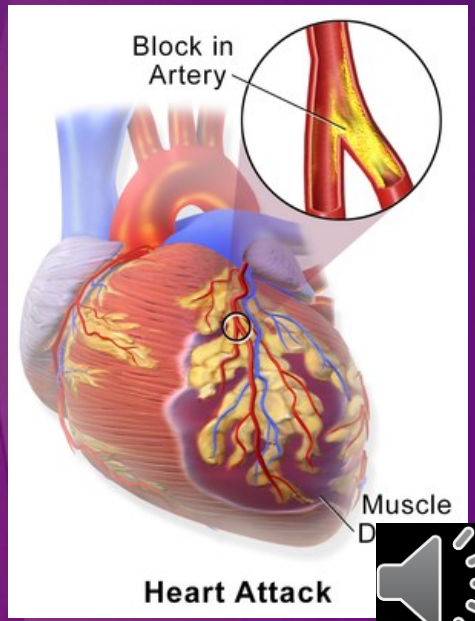
Source: https://en.wikipedia.org/wiki/Stem_cell

Luong-Van et al, 2020
https://www.sciencedirect.com/science/article/pii/S246851942030010

Stem cell regeneration

- A human stem cell model has also been used to mimic cell regeneration from acute myocardial infarction (MI) using graphene in the form of hydrogels:
- less infarct area and
- more blood vessels



Si et al 2020
www.sciencedirect.com/science/article/pii/S101113441931629X?via%3Dihub

Source of photo- https://en.wikipedia.org/wiki/Myocardial_infarction

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Evidence for heart regeneration

- enhanced cell survival rate, increased expression of pro-inflammatory factors,
- factors that aid in the formation of new blood vessels, and early cardiogenic biomarkers,
- using graphene quantum dots as a soft injectable hydrogel for heart regenerative function after MI.

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Thank you very much for your attention!

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