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Nanotechnology: Energy and Environment

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Article

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Abstract

This study highlights how nanotechnology and application of the graphene may sort out humanity's top ten issues for the next thirty years ahead. Delivering sufficient energy and potable water continuously and low cost are the main two concerns among others. This research is accompanied by three case studies to identify how these issues are implemented through nanotechnology.

1. Introduction

Carbon is an essential element of life and is also one of the most abundant elements on earth. A well-known example of carbon is the tip of pencils which consists of graphite (layers of carbon atoms). (1 nm= 10 numbers of atoms in thickness). Each layer of carbon atoms forms a honeycomb structure which is called graphene. Professor Richard E. Smalley 1943-2005 (Nobel prize in Chemistry 1996 for the discovery of the Buckyball C60) [9] hydrogen atom diameter). Andre Geim and Ostia Novoselo won the Noble Prize for Physics in 2010 for their work with graphene. Although scientists knew that graphene layers are the constituents for graphite, for years they were not sure whether a monolayer of graphene could be isolated in nature. Until 2004, when two British physicists finally demonstrated that a single atomic layer of graphene can be isolated and stabilized in nature.

These two scientists not only demonstrated that graphene can be isolated and stabilized in nature, but they also carried out detailed studies of the properties of graphene. They found that graphene exhibited very interesting and unique properties that could be promising for a wide range of applications. Therefore, their research ignited great excitement throughout the world. So, what are the unique properties of graphene that make it so special?

Figure 1 shows that graphene is highly electrically and thermally conductive, so electrons on the surface of graphene can move like massless particles ballistically across the surface of graphene without being scattered. Graphene is 250 times faster electrical conductor than silicon at room temperature.

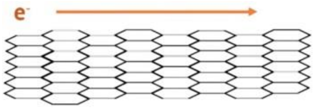

Figure 1: Electron passes through the surface of graphene [1-3]

Figure 2 represents that graphene is very thin and optically transparent, so light can penetrate through graphene without being reflected.

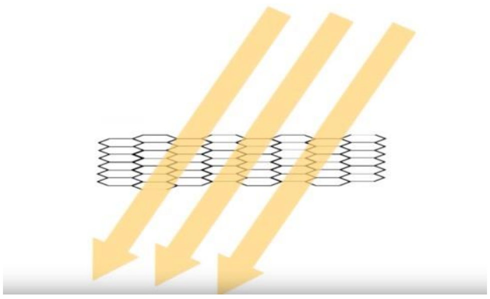

Figure 2: Transparency of graphene [4]

The edges of graphene also exhibit very interesting properties that can be functionalized for chemical applications which are shown in Figure 3.

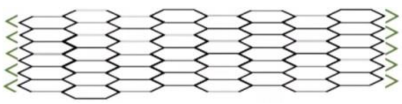

Figure 3: Graphene functionality at edges [5]

Figure 4 shows that the tiny honeycomb structure of graphene can only allow electrons and protons to penetrate through, so, for this reason, graphene can be used for filtering chemical elements.

In fact, there are two distinctly different types of edges for graphene. One is called the armchair edges, the other is called the zigzag edges. The zigzag edges usually are chemically more reactive and so can be functionalized for all kinds of chemical applications. If you take a piece of graphene and cut it into small stripes, then you have graphene nanoribbons. You can have either armchair or zigzag graphene nanoribbons. All of these nanoribbons have very large edge-to-area ratios, so they can be very effective and discharging. For this reason, graphene nanoribbons can be used in supercapacitors, batteries for energy storage.

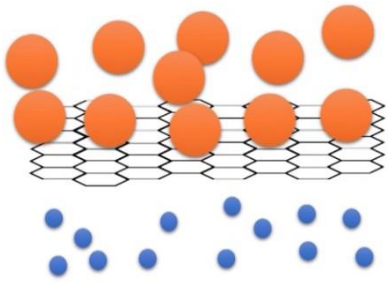

Figure 4: Electron and proton penetration through graphene surface [6]

Figure 5 displays that graphene is mechanically flexible and 200 times stronger than steel. Figure 6 shows the graphene nanoribbons which are narrow strips of graphene and significantly lower the percolation threshold in conductive films and polymer composites and render them suitable for spinning fiber from their liquid crystalline alignment [7].

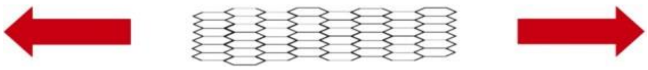

Figure 5: Flexibility of graphene [6]

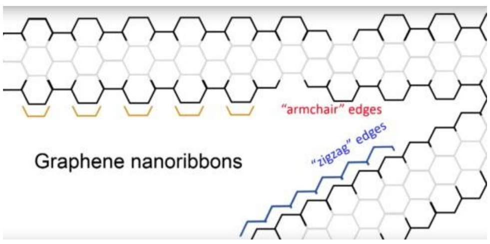

Figure 6: Graphene nanoribbon [7]

Despite all these wonderful properties of graphene, there are major challenges before we can fully realize the potential of graphene. In particular, we need to develop reliable,

- Large-scale production
- High quality
- Low cost

Currently, there are three typical methods of producing graphene.

Mechanical exfoliation from graphite (used by the two Nobel laureates). Which is involving the use of adhesive tapes or Scotch tape. You take a piece of Scotch tape, press it against graphite, and you peel it off. Then you get tiny flakes of graphite. Then you keep repeating the process until you hopefully get little flakes of graphene that can be monolayer or bilayer or multilayers [8]. This is a method that's

- Labor-intensive
- Very slow in production
- It is not scalable
- No control of the quality and size of the graphene samples.

The second method is based on chemical reduction, which utilizes very toxic chemicals to oxidize graphite into graphite oxide, and then chemically reduces graphite oxide into tiny flakes of graphene. This method, again, is:

- Environmentally unfriendly
- The produced graphene flakes are uncontrollable in size, number of layers, and quality
- The graphene flakes consist of lots of impurities.

The third method is called chemical vapor deposition, which involves using multistep, long-term processes of growing graphene on metals such as copper or nickel.
The growth process involves very, very high temperatures (1000°C). Typically, this method can produce sufficiently large areas of graphene sheets, and the quality can be reasonable if you take a lot of time to go through many steps to produce the material. Overall, this process is:

- A long-term process
- Very expensive
- Incompatible with most device fabrications

Consequently, all three methods are not ideal for fully realizing the potential of graphene.

If graphene production on a mass-scale becomes environmentally and economically feasible, then humanity's top ten problems will be solved accordingly [9]. In this research, there are three case studies that show various applications of graphene to save energy and also secure drinking water through implementing graphene nanofiltration.

2 Case study one

We can generate all the energy we need right we are, cleanly, safely, and cheaply. During summer and winter seasons. Windows can flick back/away from the lights or heat in or out of the room during day and night or during the summer season or winter season. Carbon is black, but in nanoscale is transparent and flexible.

If carbon nanotube (CNT) is combined with a polymer and fixed on the window when it is in a colored state, it will reflect away all heat and light and when it is in a bleached state, it will let all the light and heat through the window and any combination in between.
To change the state, by the way, takes two volts from a millisecond pulse. And once you have changed its state, it stays there, until you change its state again [8].

3 Case study two

Imagine if we did not have to rely on artificial lighting to get around at night. A nanomaterial, a detector, and an imager, which is highly transparent, and the total width of it is 600 times smaller than the width of a decimal place. And it takes all the infrared light available at night, converts it into an electron in the space of two small films which are transparent. (Taking infrared radiation, wavelengths, and converts it into electrons) [9].

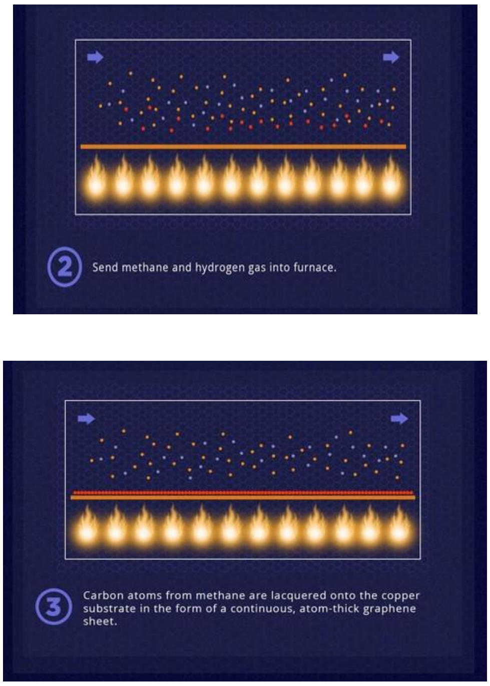

Figure 7: Graphene production through chemical vapor deposition [9]

Figure 8: Color change state of the combination of a polymer and CNT through 2 volts electric current

So, CNT/Polymer combined with these two films, convert energy into an electron on a plastic surface that you can stick on your window. Because it is flexible, it can be on any surface. Accordingly, there is not necessary to have power plants for tomorrow. Nanotechnology can generate energy cleanly, efficiently, and cheaply right where I am and if I do not need it, I can convert it back to the window and beam it to your place for energy consumption. With this technology, there is not necessary even to have a grid for tomorrow and this type of clean energy will be free one day. If these scientific concepts come through we found the last puzzle piece, Water.

Figure 9: Transparency of the combination of a detector, imager, and CNT/polymer [7-9]

4 Case study three

Earth is running out of water as it is in some parts of the world and soon to be in other parts of the world. At the moment one billion people around the world have less access to clean water and it is expected to double in 2030. 97% of Earth s water is in the oceans and seas. Desalination plants require significant investment, financial costs, high maintenance, high energy consumption and less contribution to the world’s reserve water supply making it an unfeasible process for the future. (There are 12,500 desalination plants in 120 countries that produce less than 1% of the global water supply.). So, the freshwater through water desalination is very costly (Ten times more than regular municipal water supply) [3-8].

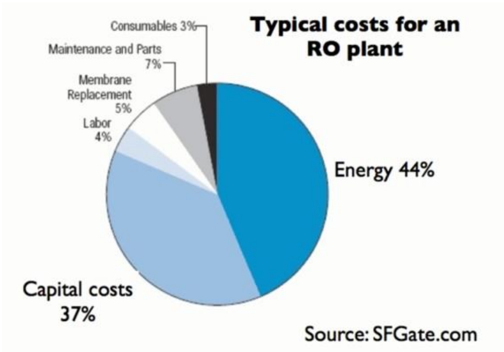

Figure:10, Typical cost of a reverse osmosis plant [3-6]

In a regular large desalination plant, there are 40,000 membranes, each membrane is in a two-meter-long tube that has inside of it wrapped up 40 m2of active membrane that gives you a sense of the scale. We have to supply water from the sea, which requires building desalination plants and securing tremendous funds (19 Trillion $). Desalination plants require tremendous amounts of energy (Twice the world´s supply of oil to run the pumps) to generate water. Nanofiltration is about 100 times more permeable (produce higher flux) than the existing polymer filters and using the graphene membrane filtration can reduce the pressure drop and energy consumption up to 50% less energy use in pushing the feedstock through the filter (depends on the different type of water for filtering) that is half of the operating cost of a desalination plant. Graphene is very strong compared to a superlight mass and the bonds between the carbons are very difficult to break with the tensile stiffness of 150,000,000 psi this ability to withstand high stresses or forces per area means that graphene can withstand a large amount of pressure as the filter stretches when the water is forced through at high fluxes. Graphene filtration can easily remove water contaminants and solve the potable water supply crisis effectively, which was not necessarily available even 10 years ago. If nanotechnology can produce energy free of charge and transmittable, then we can take any water wherever we are and turn it into whatever we need. Desalination across a graphene membrane is more effective and decreased energy and all different costs such as labor, construction, and maintenance.: Using graphene filter, hydrophobic nanoparticles, remove all the chemicals that are in the water [8].

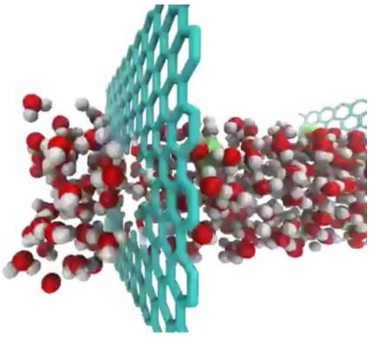

Figure 11: Graphene as a desalination membrane [8]

4. CONCLUSIONS

If this study tends to produce energy through a convenient procedure and secure freshwater from saltwater at a low cost that will be indeed a great service to humanity and will dwarf any other scientific accomplishment (Jonn F. Kennedy, 1962).

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