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Role of Graphene Sheets in Controlling Effects of Radon Decay in Human Cells

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Abstract: It is known that Radon gas within the air could reach lung cells and cause cancer. We suggest a technique to absorb alpha particles radiated by Radon decay near DNAs within human cells. In this technique, we create some non-paired negative electrons on graphene sheets and build some negative graphene tubes. Alpha particles are attracted and negative beta particles are repelled by the graphene tubes.

Keywords: radon decay; graphene sheets; cancer; Alpha particles; Beta particles; DNA

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1. Introduction

Radon is a radioactive, colourless, odourless and tasteless noble gas. Its most stable isotope, ^{222}Rn, has a half-life of only 3.8 days and could decay into some other radioactive particles which have a half-life around minutes or even ms (Partington 1957; Rutherford and Brooks 1901). At standard temperature and pressure, Radon forms a monatomic gas with a density of 9.73 kg/m^3, about 8 times the density of the Earth's atmosphere at sea level (1.217 kg/m^3). It is one of the densest gases at room temperature, and the densest of the noble gases (Kusky 2003). Since Radon is gaseous and easily inhaled, it could be a serious health hazard (Martin-Gisbert et al. 2023; Riudavets et al. 2022). In some countries like the USA, Radon is the second most frequent cause of lung cancer after smoking (Huma et al. 2022; Li et al. 2020).

To control the effects of Radon gas, we suggest the use of graphene sheets (Geim and Novoselov 2007; Peres and Ribeiro 2009) because graphene has free electrons with negative charges which could control radiated charges from the decay of Radon (Gong et al. 2020; Zhou et al. 2023). In this article, we consider this subject in detail.

2. Radon Atoms and Lung Cancer

Radon could decay to alpha particles and polonium. Polonium could also decay into some daughters and each product could decay up to stable particles like some isotopes of lead. Some of the daughters like ^{214}Pb has a lifetime around several minutes and some others like ^{214}Po have a life time of the order of ms. Thus the velocity of decay of particles is far from expectation. During these decays, many charges like positive alpha particles and negative beta particles are produced. These particles could interact with other charges and repel or attract them - see Figure 1.

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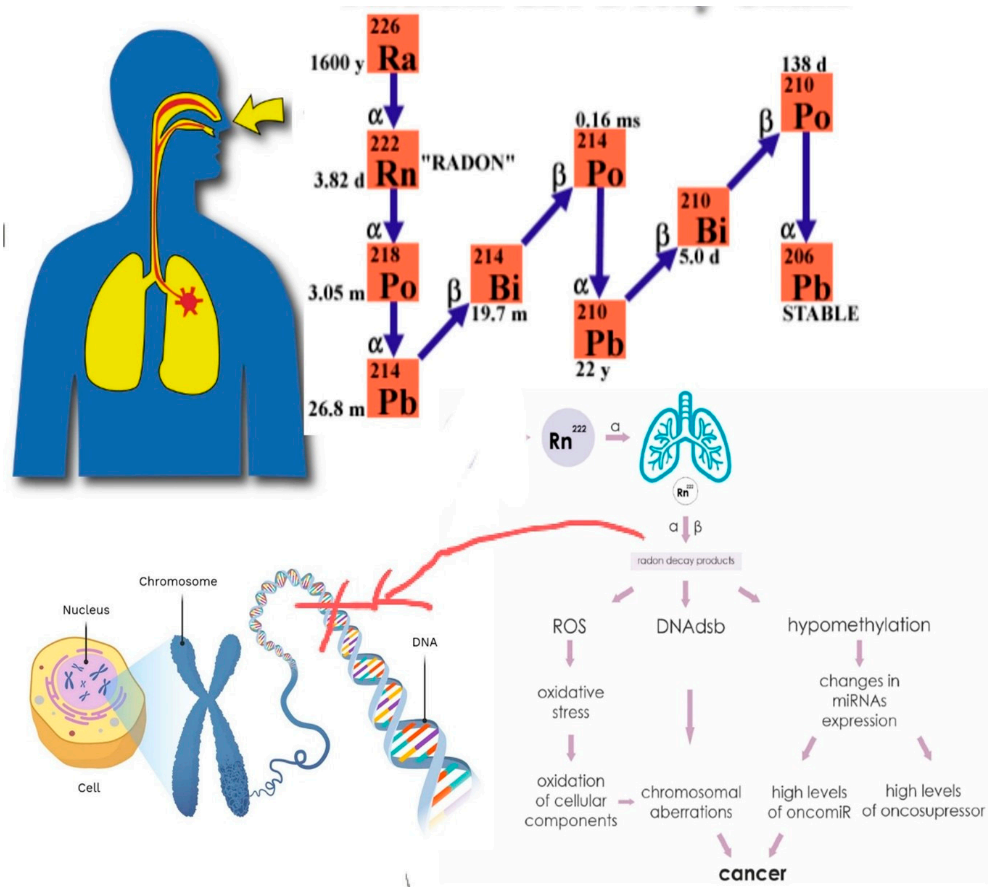

Figure 1. Radon particles could enter a human body and decay into some particles like alpha particles which could cause the emergence of tumors.

Now the question that arises is whether Radon and its daughter nuclides are harmful to humans? radon exists in the air, soil and water and could enter into a human body through the mouth and other pores, especially during breathing. Then, Radon could reach the lungs - see Figure 2 (together with Figure 1).

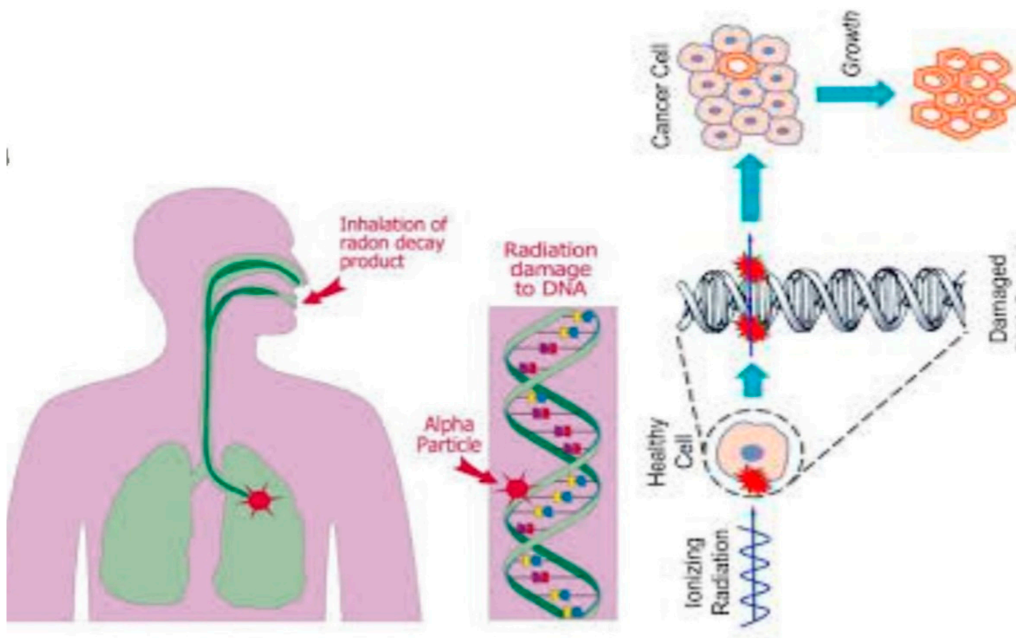

Figure 2. Alpha particles could break some connections between bases in a DNA and produce new connections which may cause the emergence of cancer.

Within the lung cells, Radon decays into its daughters and alpha particles. The energy of these particles could be around several MeV. These particles collide with DNA bases and disconnect them. In fact, some connections disappear and new connections appear. This causes some mutation which may be the main reason for the appearance of lung cancers - See Figure 3.

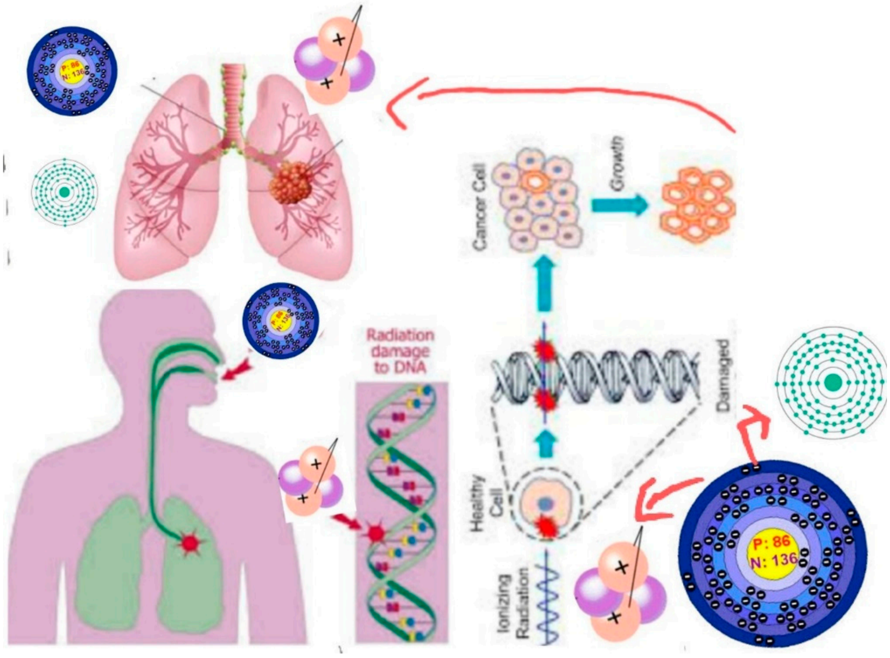

Figure 3. Radon atoms could cause some special tumors like lung cancer.

Radon gas within the air could also have other effects. Energetic particles like alpha and beta particles increase the temperature within the cell and provide good conditions for disconnection of all base pairs and the beginning of the process of replication and transcription. Between two decays, the temperature decreases and polymerases and replication factors could have the opportunity to produce some copies of genetic information. Then, bases connect with each other and instead of a DNA, we could have two DNAs or a DNA and an RNA. This means that some extra replications and transcriptions occur. These extra events may be another reason for the emergence of tumors.

3. Graphene Could Control Effects of Radon Gas

A graphene sheet is formed from carbon atoms. Each carbon atom has four free electrons which could be paired with four electrons of another carbon atom. One of these pairs could be broken and produce two non-paired electrons. These negative charges could attract positive charges like alpha particles - See Figure 4.

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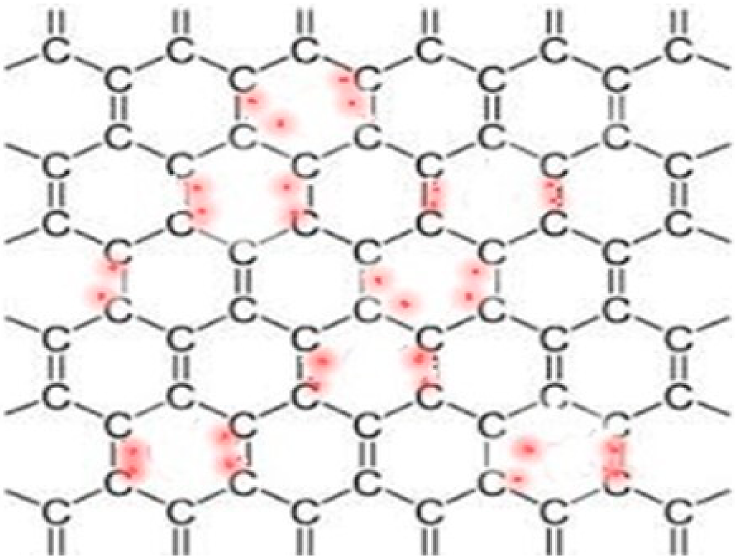

Figure 4. A graphene sheet could have some non-paired electrons.

To confine alpha particles, one can build a tube with one or two ends open. Alpha particles with positive charges could enter these graphene tubes and be attracted by negative charges of free electrons. These electrons are non-paired electrons of carbon atoms within the graphene structure - See Figure 5.

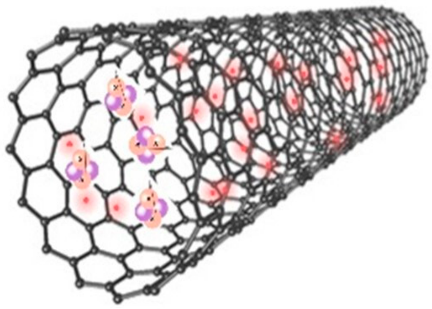

Figure 5. Tubular graphene may have some unpaired electrons which absorb charged alpha particles.

One can use these properties of graphene sheets in controlling Radon gases within cells. Each Radon atom decays into charges like alpha particles and some daughters. These alpha particles are attracted by non-paired electrons within the graphene tube or sheets and are trapped or confined. These alpha charges could not have any effect on DNA bases and change their structures. Thus graphene has a main role to play in the prevention of lung cancers - See Figure 6.

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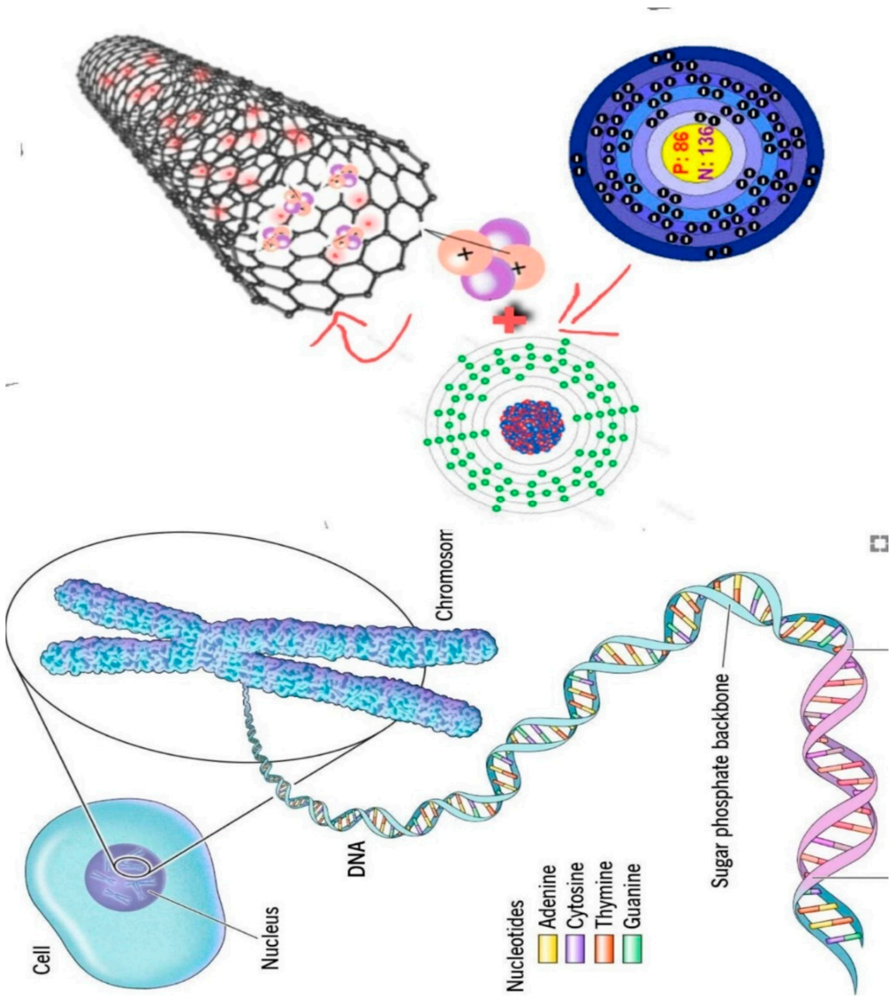

Figure 6. Charged tubular graphene could absorb radiated alpha particles from radon atoms.

A graphene molecule has nano size and thus could have the best effect on nano particles like DNA. In addition, graphene has hexagonal molecules which could interact with the hexagonal bases of DNA. If we produce some defects in graphene, we can produce some pentagonal molecules which interact with the pentagonal bases of DNA. If graphene sheets are coiled several times, their structures come closer to the DNA. However, non paired electrons of graphene sheets could be closer. Thus, they can attract alpha particles which are radiated by Radon gases more than the DNAs. This helps us in controlling the effects of Radon gases.

In addition to the alpha particles, the daughters of Radon emit some beta particles also, which are negatively charged. Graphene repels these particles and causes their escape from DNA because non-paired electrons of a graphene sheet repel beta particles and prevent from their getting close to DNA structures. Thus, graphene could control beta particles also.

4. Estimate of Needed Graphene Charges to Control Radon Radiation

To obtain the physical properties of the needed graphene sheets to control radon radiation, we need to know the physics of the nuclear products of radon decay. In Table 1, we present some changes in the physical properties like changes in masses, sizes, radiation, densities and also the required times for transition. We choose two transitions, viz., from Radon to a stable atom like lead (^{206} Pb), and secondly, from Radon to polonium (^{214} Po). The required time for the first transition may be several years, but the required time for the second transition is less than 4 days. On the other hand, ^{214} Po is very unstable, and decays very fast. Thus, this transition is more dangerous. During these transitions, many charges like positive alpha and negative beta particles are radiated. By this radiation, the masses and densities of the initial particles change, and most of this energy is stored as the kinetic energy of the radiated alpha and beta particles. We should calculate the amount of radiated charge in each second and nm ^{3}. This helps us to design a graphene sheet to absorb or repel these charges.

To calculate the amount of radiation, we begin with the Radon density:

Density = 9.73 kg/m^3

The Radon mass:

Radon mass = 222 u = 222 × 1.661 × 10^{-24} g = 368.7 × 10^{-24} g = 3.687 × 10^{-25} kg

By dividing the density by the mass, we can obtain the number of Radon atoms in each m^3:

Number of Radon atoms per m^3 = 9730 × 10^{24} / (222 × 1.661)/m^3

The DNA dimensions are of the order of nm, and thus we should obtain the number of Radon atoms per nm^3:

Number of Radon atoms per nm^3 = 10^{-27} × 9730 × 10^{24} / (222 × 1.661)/nm^3

These Radon atoms emit 4 to 7 alpha atoms to reach the stable state:

Number of radiated alpha particles in a nm ^{3} = 4 to 7 × 10 $^{-27}$ × 9730 × 10^{24} / (222 × 1.661)/nm^3

Each alpha particle has two positive charges and thus we have:

Number of radiated positive charges in a nm ^{3} = 2× (4 to 7)× 10 $^{-27}$ × 9730 × 10^{24} / (222 × 1.661)/nm ^{3}

The same calculations could be done to obtain the number of radiated beta particles in each nm^3:

Number of radiated beta particles in a nm ^{3} = 4 to 7 × 10 $^{-27}$ × 9730 × 10^{24} / (222 × 1.661)/nm ^{3}

Number of radiated negative charges in a nm ^{3} = 1× (4 to 7)× 10 $^{-27}$ × 9730 × 10^{24} / (222 × 1.661)/nm ^{3}

The above numbers are related to the total positive and negative charges which are radiated during four or more days. To obtain the amount of radiated charges in each second, we should consider all half-life times up to at least polonium:

Number of radiated positive charges in nm ^{3} and in each second =

= Number of radiated positive charges in nm^3 /(3.82 day ×60×60 + 3.05 m ×60+ 26.8m ×60 + 19.7 m ×60 + 0.16 ms) =

2× (4 to 7)× 10 $^{-27}$ × 9730 × 10^{24} / (222 × 1.661)/nano ^{3} /((3.82 day ×60×60 + 3.05 m ×60+ 26.8m ×60 + 19.7 m ×60 + 0.16 ms)

Number of radiated negative charges in nm ^{3} and in each second =

=Number of radiated negative charges in nano ^{3} /(3.82 day ×60×60 + 3.05 m ×60+ 26.8m ×60 + 19.7 m ×60 + 0.16 ms)=

1× (4 to 7)× 10 $^{-27}$ × 9730 × 10^{24} / (222 × 1.661)/nano ^{3}/(3.82 day ×60×60 + 3.05 m ×60+ 26.8m ×60 + 19.7 m ×60 + 0.16 ms)

Now, we can estimate the amount of radiated charges in each nm ^{3} and in each second:

Aproximate radiation charges in each second and each nm ^{3} = 10 $^{-4}$

This is the needed charge for controlling the radiation of Radon atoms near DNA molecules. Using these calculations and Table 1, we can consider the physical properties of the needed graphene sheets to control Radon radiation. It is clear that the number of free charges on the graphene sheets should be more than 10^{-4}. The size of the graphene sheets should be more than the changes in the sizes of the nuclear atoms during transitions, and the mass of the graphene sheets should be more than the differences between the nuclear masses in Table 2. By using this information, we can design some effective graphene sheets, and control Radon radiation within cells.

Table 1. Physical changes in properties of nuclear atoms during transition.

	^{222} Rn to ^{206} Pb	^{222} Rn to ^{214} Po
Change in mass	222 u -207.2 u	222 u-213 u
Change in size	200 pm -180 pm	200 pm – 168 pm
Change in radiation	4 -7 alpha +4-7 beta	2-5 alpha +2-5 beta
Change in density	9.73 g/litre – 11.34 g/cm ^{3}	9.73 g/litre -9.196 g/cm ^{3}

Time period for transition	3.82 d + 3.05 m+ 26.8 m+19.7m+0.16 ms+ 22y +5d+136d	3.82 d + 3.05 m+ 26.8 m + 19.7 m

Table 2. Physical properties of graphene sheets to control Radon radiation.

	Graphene properties
Density of charges in nm ^{3} and second	10 $^{-4}$
Size of graphene sheet	More than 32 pm and less than 20 nm
Mass of graphene sheet	Between 9 u to 15 u
Number of graphene sheets	Around 14600 distributed in 4 days

5. Conclusion

Radon is a harmful gas in nature that could cause lung cancer. This radioactive particle decays to more harmful particles with smaller half-life. During these decays, many alpha and beta particles are emitted. We have described that by designing special charged graphene tubes, we can take alpha particles and confine them. These graphene tubes also could repel beta particles. Thus, by putting these graphene tubes near human cells, we can begin the move towards the prevention of lung cancers.

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