

Review Article On: Boron Chemistry And Application To Cancer Treatment

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Abstract- Boron compounds now have many applications in a number of fields, including medicinal chemistry.

The boron containing compounds epitomize a new class for medicinal chemists to use in their drug designs. Carboranes are a class of organometallic compounds containing carbon (C), boron (B), and hydrogen (H) and are the most widely studied boron compounds in medicinal chemistry.

The boron neutron capture therapy (BNCT) has been utilized for Cancer treatment from last decade, where chemotherapy and radiation have their own shortcomings. BNCT integrates the fundamental focusing perception of chemotherapy and the gross anatomical localization proposition of traditional radiotherapy.

Keywords- carboranes, carbon, boron, hydrogen, BNCT, cancer, radiotherapy

I. INTRODUCTION

Introduction to boron

- Boron is chemical element with the symbol B.
- Atomic number -5
- Atomic mass-10.811u
- electronegativity-2.04
- Vander waals radius -180pm
- Boron is a metalloid in group 13.
- P-block of the periodic table.
- Difficult to prepare, at room temperature.

Pressure it forms a solid that melts at 2076 degrees celcius.

Boron



Boron physical properties

- It is a hard & black coloured non metallic solid.
- The existence of boron can be seen in its many allotropic forms.
- It has an unusually high melting point because of the very strong crystal lattice.

They have high electrical conductivity.

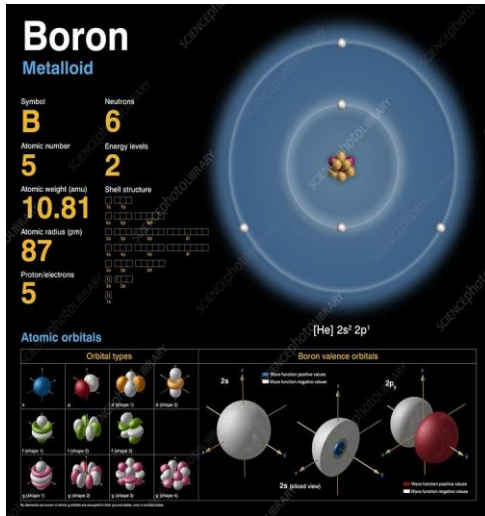
Boron chemical properties

- Boron combine with oxygen in the air to form boron trioxide (B₂O₃).
- Boron trioxide forms a thin film on the surface that prevents further reaction with oxygen.
- Boron is not soluble in water.
- It normally does not react with acids.
- In powder form it reacts with hot nitric acid (HNO₃) & hot sulfuric acid (H₂SO₄).
- It also dissolve in molten (melted) metals.

Boron uses

- Boron is used for building strong bone.
- Treating osteoarthritis.
- As an aid for building muscle.
- Increasing testosterone level.
- For improving thinking skills & muscle coordination.

BORON ATOMIC STRUCTURE



II. INTRODUCTION TO CANCER

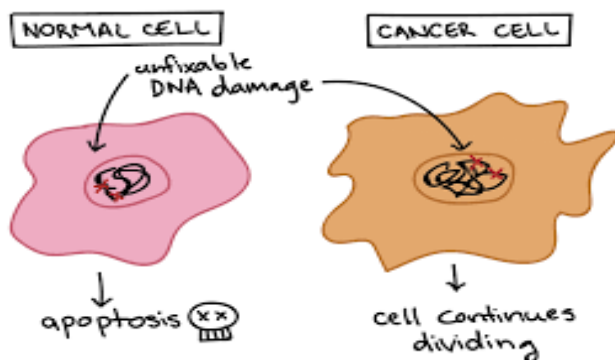
Definition- Cancer is a group of diseases involving abnormal cell growth with the potential to invade or spread to other parts of body.

History of cancer: The diseases was first called cancer by Greek physician Hippocrates.

He is considered the father of medicine.

History of cancer treatment

- The history of chemotherapy began in the early 20th century, but its use in treating cancer began in the 1930s.
- The term “chemotherapy”. Was coined by the German scientist Paul Ehrlich,
- who had a particular interest in alkylating agent & who came up with the term to describe the chemical treatment of disease



Type of Cancer

1. Bladder cancer
2. breast cancer
3. Colorectal cancer
4. Kidney cancer
5. Lung cancer
6. Lymphoma
7. Melanoma
8. oral&oropharyngeal
9. Pancreatic cancer
10. Prostate cancer
11. Thyroid cancer
12. Uterine cancer

Cancer signs & symptom

- Fatigue .
- Lump or area of thickening that can be felt under the skin.
- Weight changes including unintended loss or gain.
- Skin changes such as yellowing, darkening or redness of the skin ,sores that won't heal or changes to existing moles.
- Changes in bowel or bladder habits.
- Persistent cough or trouble breathing.
- Difficulty swallowing .
- Hoarseness
- Persistent indigestion or discomfort after eating
- Persistent unexplained fevers or night sweats
- Unexplained bleeding or bruising.

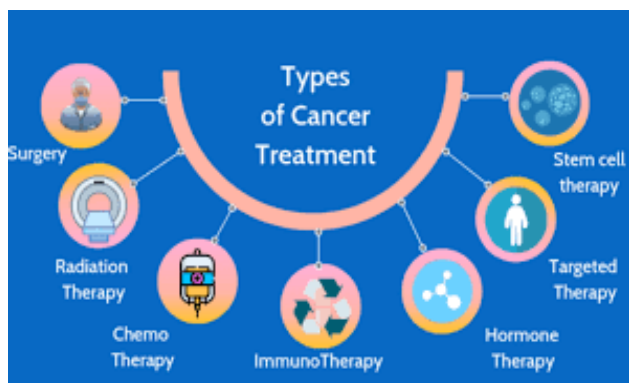
Cancer risk factor

- Older age.
- A personal or family history of cancer.
- Using tobacco.
- Obesity.
- Alcohol.
- Some types of viral infections such as human papillomavirus (HPV).
- Specific chemicals.
- Exposure to radiation including ultraviolet radiation from the sun.

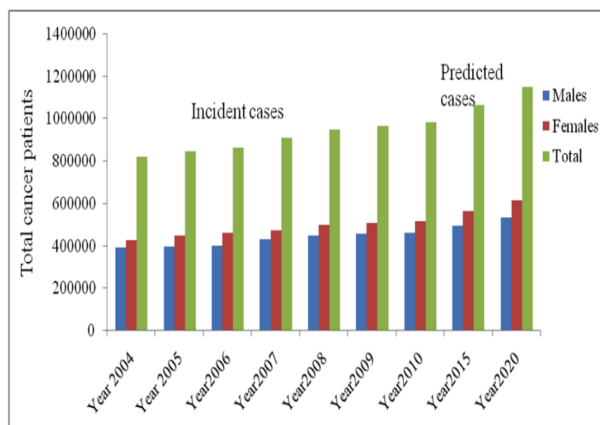
Cancer prevention

- Don't use tobacco.
- Eat a healthy diet.
 - Eat plenty of fruits & vegetables.
 - Maintain a healthy weight.

- If you choose to drink alcohol do so only in moderation.
- Limit processed meats.
- Maintain a healthy weight & be physically active.
- Protect yourself from the sun .
 - Avoid midday sun.
 - Stay in the shade .
 - Cover exposed areas.
 - Don't skimp on sunscreen.
 - Avoid tanning beds & sunlamps.
- Get vaccinated.
 - Hepatitis B.
 - Human papillomavirus (HPV).
- Avoid risky behaviors.
 - Practice safe sex .
 - Don't share needles.
- Get regular medical care.



Cancer ratio in india



BORON CHEMISTRY

Boron neutron capture therapy (BNCT) is a radiation science which is emerging as a hopeful tool in treating cancer by selectively concentrating boron compounds in tumor cells & then subjecting the tumor cell to epithermal neutron beam radiation.

***Techniques using Boron ***

1. Boron –nitride nanotube technique (BNNT)
2. Boron neutron capture therapy (BNCT)

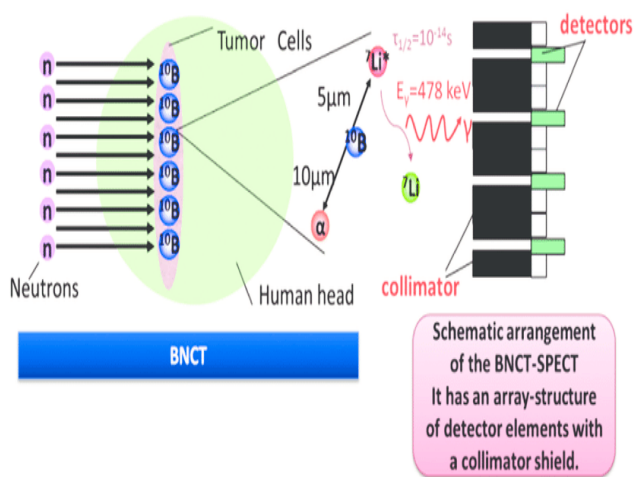
Principle of Boron –nitride nanotube technique (BNNT)-

- Boron nitride nanotube are introduced into the cancerous cells it is a way of putting holes in wall of a tumor cell.
- This hole could trigger cell suicide .
- The cell will literally go ,oh something terribly wrong ,&kill itself thats called apoptosis.
- The researchers determined the amount of BNNTs that killed roughly 25 percent of the cancer cells over 24 hours.

Principle of Boron Neutron Capture therapy (BNCT)

Principle of BNCT is two component system ,

Based on nuclear reaction that occurs when the stable isotope boron-10 is irradiated with low energy or thermal neutrons to yield highly energetic helium-4 (4He) nuclei (alpha particles) & recoiling lithium-7 (7Li) ions



Boron neutron capture therapy

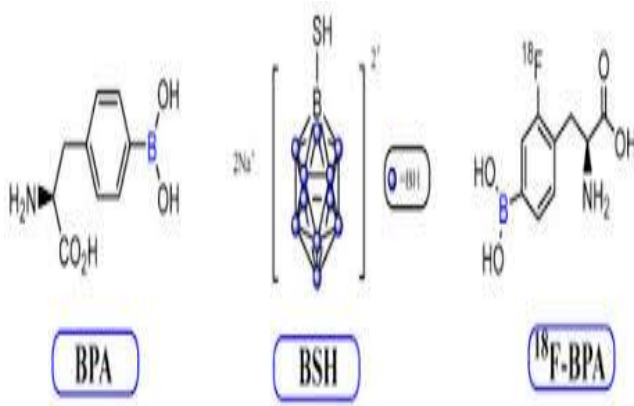
- History - After the initial discovery of the neutron in 1932 by sir James Chadwick .
- H.J.Taylor in 1935 showed that boron-10 nuclei had a propensity to capture thermal neutrons.This results in nuclear fission of boron-11 nuclei in stripped down helium-4 nuclei & lithium-7 ions.
- In 1936 G.L.Locher ,a scientist recognized the therapeutic potential of this discovery & suggested that neutron capture could be used to treat cancer.

- W.H.Sweet, first suggested the technique for treating malignant brain tumors & a trial of BNCT against the most malignant of all brain tumors, glioblastomultiforme, using borax as the boron delivering agent in 1951.

Clinical trials

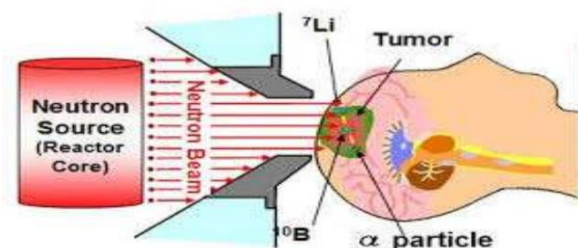
- In 1980 a clinical trial was started which centered on glioblastomultiforme
- In 2001 an experiment using BNCT irradiated an explanted liver suffering from diffuse metastases took place in Italy.
- In 2003, BNCT used to treat skin melanoma.

Boron delivering agent



1. Polyhedral Borane anion, Sodiumborocaptate or BSH ($Na_2 B_{12} H_{11} SH$)
2. Dihydroxyboryl derivative of phenylalanine referred to as boron phenylalanine or BPA.
3. These delivering agents are introduced into the body through intravenous infusion.
4. These delivering agents highlights the infected areas (tumor cell). The low energy radiations interact with B-10 in the tumor cell to produce B-11 isotope.
5. B-11 through fission reaction produce 2.31MeV energy.

BNCT TREATMENT PROCESS



Neutron sources

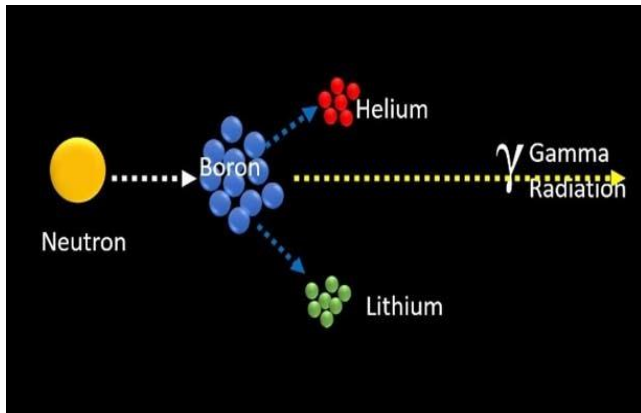
1. Nuclear reactor
2. Accelerator



BNCT how to work-

- BNCT is a possible treatment methodology for cutaneous melanomas, extramammary paget's diseases of genital regions, vulvar melanoma, neck & head cancers & high-grade gliomas.
- The effectiveness of BNCT depends mainly on the boron concentration & its distribution in targeted tumor cell.
 - Recently the most common boron carrier – Boronophenylalanine (BPA) labelled with fluorine 18 (^{18}F -BPA) has been developed & successfully applied for monitoring the pharmacokinetics of BPA with positron emission tomography (PET).
- Which allows obtaining information about the tumor as well as evaluating the boron accumulation in both the tumor & normal tissue.
 - For BNCT to be more successful in destroying the tumor cells, cell targeting agent containing a higher no. of boron-10 isotope in their structure should be developed.

BNCT depend on following nuclear reaction – Non-radioactive isotope ^{10}B atoms absorb low energy ($<0.5\text{eV}$) thermal neutrons & subsequently breaks up into alpha particle (Helium-4) & a recoiled lithium nucleus (7Li)



- Strength of BNCT, & what has made it the focus of so much research, is that unlike other forms of radiation therapy.

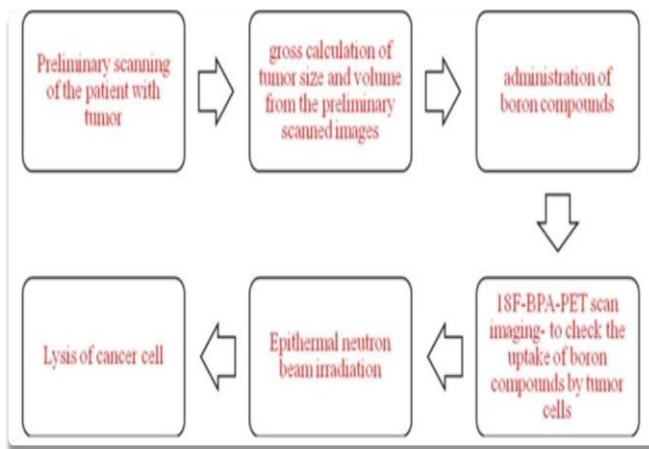
Disadvantages of BNCT

- undesirable dose components produced as an unavoidable side effect (like gamma rays)
- Well trained surgeon.

Uses of BNCT

- Liver cancer-Hepatic tissue morphology preserved from radiotherapy.
- Require heavy operation difficulty of determine produce length fast system for infusion of blood well trained surgeon.
- Brain tumor (Gliomas, Glioblastoma) & skin cancer (melanoma)-in Japan BNCT treatment equipment present (50% patient survive)
- Lung disease-lung tissue are radio-sensitive so conventional therapies are not effective for its treatment.

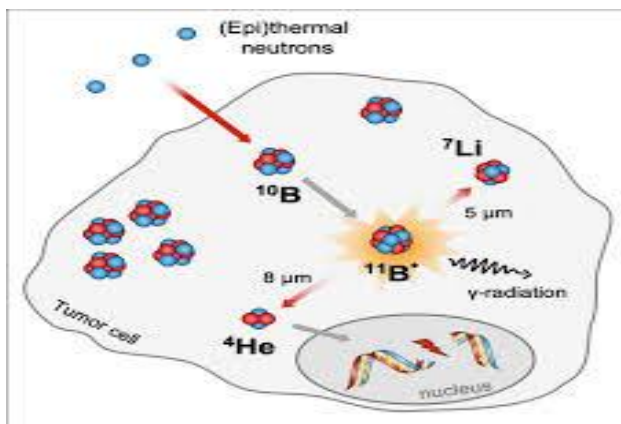
Procedure of BNCT by block diagram



Application of Boron to cancer treatment

- One of the uses of boron is in treatment of cancer.
- BNCT is basis of boron capture therapy for cancer treatment.
- The first components that is a stable isotope of boron (boron-10) that can be concentrated in tumor cells by attaching it to tumor seeking compounds.

BNCT reaction



Advantages of BNCT

There are two key advantages to the use of BNCT which make it particularly effective in the treatment of tumors.

- The reaction on which BNCT produces various type of radiation.

III. CONCLUSION

In conclusion boron is an element with various function & most importantly in cancer treatment due to its ability to absorb neutrons. This development will be able to provide cancer patients with a treatment option that allows for less damage to the rest of their bodies thus increasing the chance of survival.

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