

Catastrophe in the Nanoworld: Noah's Ark to the Rescue

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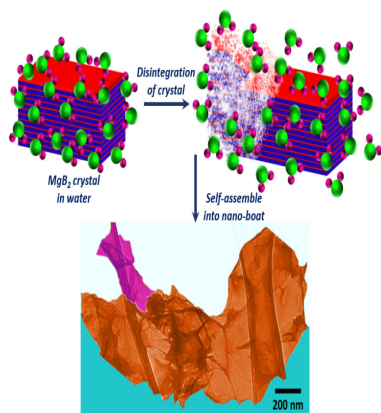
Our world has experienced several catastrophic events; and perhaps the earliest account of one such event is “The Great Flood”, which finds its place in the folklore of several cultures across the world. This global flood, which is believed to have wiped almost the entire life on earth, is also considered to mark the beginning of a new life cycle in several cultures. The accounts of “The Great Flood” are incomplete without the mention of *Noah's Ark* – a ship that was able to survive the global flood, and helped in reviving the life back on the earth. While there are mixed opinions on whether or not Noah's Ark existed, it has become a symbol of rescue. Do you think that Noah's Ark exists? Well, let me share with you a set of events that I came across in a test tube while investigating the world of nanomaterials; interestingly I found that these events bear a close resemblance to the story of *Noah's Ark*!

The scale at which these events occurred was extremely small around one-lakh times thinner than a human hair! What were these events? How did I come across these?

Let me take you through my journey, which took an unexpected turn and led me to these events.

In my research, I was investigating a famous material Magnesium diboride (MgB_2). Hmm! You may be thinking what is so special about this material. Well, this compound is a well-known superconductor; it can conduct electricity with no resistance. Its specialty is that it shows superconductivity at a higher temperature compared with other superconducting materials.

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Electron microscope image of nano-boat
(Noah's Ark to the rescue)

One day, I was curious to know whether this material can withstand water or not. To test this, I placed the MgB_2 crystals in water, and to my surprise, I observed that the crystals were disappearing in water and forming a golden yellow solution. It was as if a flood had destroyed the crystals. I was even more surprised to see that the yellow colour was not permanent; it started fading and turned into clear water again. What could have happened to the MgB_2 crystals after experiencing the catastrophe? I started to closely observe the solution to figure out what could be happening, but I could not see anything. Then I realised that something is happening beyond what we can see with our human eyes. I tried to observe the solution under a normal microscope. To my disappointment, I was not able to see anything again. Then I remembered my teacher telling me that there exists an advanced microscope,

called an electron microscope, which can help us see what happens in the atomic world. Following this, I started observing the solution under an electron microscope. Did I start seeing something? Yes, what I observed was unbelievable. There were a large number of extremely thin structures floating in water – the thickness of all these structures was very small, **~ one-lakh times thinner than a human hair!** On the one hand, I was happy because I could finally see something. On the other hand, I was puzzled, because I saw that some of these ultrathin structures were very small like dots, some structures were a bit larger like discs, and some structures were even larger like sheets. However, I was unable to understand how these were forming.

For a long time, I could not understand this mystery, until one day when I was observing the pictures side by side, in a flash, I was able to connect all the dots.

I realised that I was witnessing a miracle in the Nanoworld. In essence, when the MgB_2 crystals were placed in water, they lost their structure and disintegrated into atoms, as if these were hit by a catastrophe. These atoms started communicating with each other and worked together in a united form to assemble in the shape of nano-boats. These nano-boats were very special because water was not able to disintegrate them further, and because of this, they happily kept sailing in water. Did these atoms also know about *Noah's Ark!*

Whether Noah's Ark exists or not, I realised that the Nanoworld was trying to tell us that with unity and resilience, it is possible to overcome any challenge. Although the entire crystal lost its identity, it came back together in the form of nano-boats; like how new life comes into existence after "The Great Flood". This phenomenon truly captured the saying that, "Every ending has a new beginning." The newly formed nano-boats started showing properties, which were not present in MgB_2 . I have started to find that these nano-boats have the ability to not only store hydrogen gas but also generate hydrogen gas, which would help several existing technologies. I am now investigating

if we can utilise their storage ability to prepare batteries of much higher capacities, paving the way for an electric future. I also found that these nano-boats were boron-rich and naturally forming the honeycomb structures of boron, which are analogous to graphene. These boron-rich nano-boats also can overcome the current limitations of the fuel-rich propellants for space exploration.

I have always believed that everything happens for a reason; one small curiosity to understand how the material would behave in the presence of water led us to the above discovery. If we keenly observe nature, there is so much to explore and find many new wonder materials, which may transform our way of living.

Our efforts of discovering a simple route to produce two-dimensional honeycomb planes of boron from a simple binary compound MgB_2 when put in the water adds a great knowledge to the growing science on two-dimensional boron nanomaterials as well as to the science of superconducting material- MgB_2 . This discovery was published in the journal *ChemPhysChem* by Wiley publishers in 2018.

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