2023 CHEMISTRY NOBEL PRIZE: WHAT ARE QUANTUM DOTS AND WHAT IS THE RESEARCH THAT WON THE PRIZE?

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Winners of the 2023 Nobel Prize in Chemistry on the screen: scientists Moungi Bawendi, Louis Brus and Alexi Ekimov, for discovery and synthesis of quantum dots. | Photo Credit: AP

The story so far: The 2023 Nobel Prize in chemistry was awarded to Moungi G. Bawendi, Louis E. Brus and Alexei I. Ekimov on Wednesday for the discovery and synthesis of quantum dots. These nanoparticles have wide-ranging applications across fields like electronics, advanced surgery, and quantum computing.

The prize itself was embroiled in some controversy earlier when the names of winners were reportedly leaked to a Swedish newspaper. But Johan Åqvist, the chair of the deciding committee, said the decision hadn't been final at the time. "There was a press release sent out for still unknown reasons. We deeply regret that this happened. The important thing is that it did not affect the recipients in any way," he was quoted as saying by *The Guardian*.

Quantum dots are particles that are a few nanometres wide. They exhibit unique optical properties due to their small physical size. Their structure and atomic composition are the same as bulk materials, but the properties of the latter don't depend on their size.

In fact ,the properties of quantum dots can be changed by changing their size.

At the scale of nanometres, materials and particles are capable of new, size-dependent properties because quantum physical forces start to dominate. At the macroscopic scale, on the other hand, like in our day to day lives, gravity and the rules of classical physics dominate.

By the 1970s, physicists knew that the optical properties of glass could be changed by adding a small amount of another element, like gold, silver, cadmium, sulphur, or selenium. They also knew how or why some of these changes could occur, but quantum dots as such hadn't been synthesised yet.

In the early 1980s, Dr. Ekimov succeeded in creating size-dependent quantum effects in coloured glass. From 1979, he studied the properties of glasses that were tinted with copper chloride, heated to a high temperature, and then cooled. He found that different ways of preparing this glass led to it absorbing light differently. This happened because the copper chloride formed tiny crystals, and that crystals of different sizes—depending on the preparation process—interacted with light differently.

In 1983, Dr. Brus and his colleagues went a step ahead and prepared similar crystals in a liquid solution, rather than in a glass. This allowed the researchers to better manipulate and study the crystals. These crystals also interacted with light differently depending on small variations in their size.

Finally, in 1993, Dr. Bawendi and his coworkers developed a technique to make these peculiar crystals—i.e. the quantum dots—of well-defined sizes and with high optical quality. This process began by injecting some substance (of which the dot would be made) into a hot solvent and then heating the solution. Nanocrystals automatically began to take shape, and larger particles formed when the solution was heated for longer. The solvent also ensured that the crystals had a smooth outer surface.

This method was quite easy, which meant many scientists could use it to make quantum dots that they required and study them.

Today, one of the simplest applications of quantum dots is to light computer monitors and television screens. Blue LEDs behind the screen excite these dots, causing them to emit light of different colours. Combining these colours gives rise to even more colours as well as brightness.

Nanoscale-sized quantum dots are also used to map biological tissues by biochemists.

Quantum dots are also used in photovoltaic cells to improve the absorption and efficiency in converting solar light into electricity.

Certain cancer treatments use quantum dots for targeted drug delivery and other therapeutic measures. This has wider applications in the field of nanomedicine too.

Quantum dots can be used as security markers on currency and documents as an anti-counterfeit measure. Broadly, they can be used as fluorescent markers to tag and track objects.

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