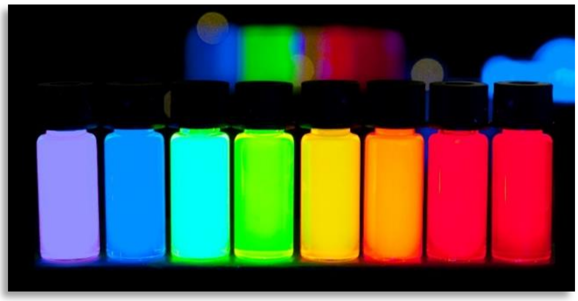
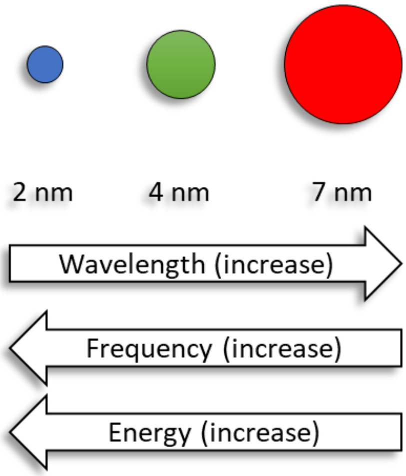
Quantum Dots Exploration Kit



A quantum dot (QD) is a tiny speck of matter so small that it's effectively concentrated into a single point. QDs are crystals a few nanometers wide, so they're typically a few dozen atoms across and contain anything from perhaps a hundred to a few thousand atoms. They're made from a semiconductor such as silicon. And although they're crystals, they behave more like individual atoms—hence the nickname artificial atoms.

School-level physics tells us that if you give an atom energy, you can "excite" it: you can boost an electron inside it to a higher energy level. When the electron returns to a lower level, the atom emits a photon of light with the same energy that the atom originally absorbed. The color (wavelength and frequency) of light an atom emits depends on what the atom is. Different atoms give out different colors of light. All this is possible because the energy levels in atoms have set values; in other words, they are quantized. Quantum dots do the same trick—they also have quantized energy levels—but dots made from the same material (say, silicon) will give out different colors of light depending on how big they are. The biggest quantum dots produce the longest wavelengths (and lowest frequencies), while the smallest dots make shorter wavelengths (and higher frequencies); in practice, that means big dots make red light and small dots make blue, with intermediate-sized dots producing all other colors.



Smaller QDs need more energy to get excited (more energy = higher frequency = shorter wavelength) and they also emit light of higher energy. Larger QDs can be excited with light of smaller energy and give out light of lower frequencies (and longer wavelengths).

Quantum dots can be produced either by physical means (like controlled evaporation of atoms onto the surface, where they assemble into the clusters), or more easily by chemical synthesis.

Applications of QDs utilize their unique electronic properties. Currently QDs are used in telephone and TV displays to achieve more vivid colours, in lightning to decrease the bluish touch of the light and make it more natural. Another promising application which is evolving now is using QDs to produce solar cells. It will probably even allow printing solar cells at home in the near future.

Quantum dots, with their remarkable quantum mechanical behavior, represent a fascinating intersection of nanoscience and quantum physics. Harnessing their unique properties opens up a myriad of possibilities for technological innovations across diverse disciplines. The principles of quantum confinement, size-dependent properties, tunable emission, and more, underpin the captivating world of quantum dots.

Experiment: Observation of Fluorescence in CdTe QDs

Objective

To prepare solutions of water-soluble CdTe quantum dots and observe their fluorescence.

Materials

- Kit of water-soluble CdTe quantum dots
- Deionized water
- Small vials or cuvettes
- UV pocket lamp
- Pipettes for accurate volume measurement
- Appropriate personal protective equipment, including gloves and safety goggles

Procedure

Preparation of CdTe Quantum Dot Solutions

1. Take a small vial or cuvette (e.g. 4-mL cuvette). Label it with a number corresponding to the number written on QDs vial.
2. Add a specified volume of deionized water using a pipette (e.g. 1 mL).
3. Carefully add a small amount of CdTe quantum dots from the kit to the water. Stir gently to ensure uniform dispersion.
   (optional: if the tutor has prepared the stock solution of QDs of high concentration, then add a defined volume of that solution into your vial).
4. Repeat the process with quantum dots of a different wavelength to create solutions.

Observation under UV Pocket Lamp

The experiment may require dimmed light. Use the UV pocket lamp to illuminate each quantum dot solution.

1. Observe and document any fluorescence emitted by the quantum dots. Note the color of the fluorescence. Using the wavelength-colour diagram estimate and write down the wavelength that corresponds to the emitted colour.
2. Thankfully, you also possess the wavelength-size graph showing the dependence between the size of some CdTe QDs particles and their luminescence maximum. Estimate and write down the size of QDs in your samples using this graph.

Safety Considerations

Handling Quantum Dots

Follow safety guidelines provided with the kit for handling water-soluble CdTe quantum dots.

UV Light Safety

Exercise caution when using the UV pocket lamp. Avoid direct exposure to eyes.

Worksheet

Title:

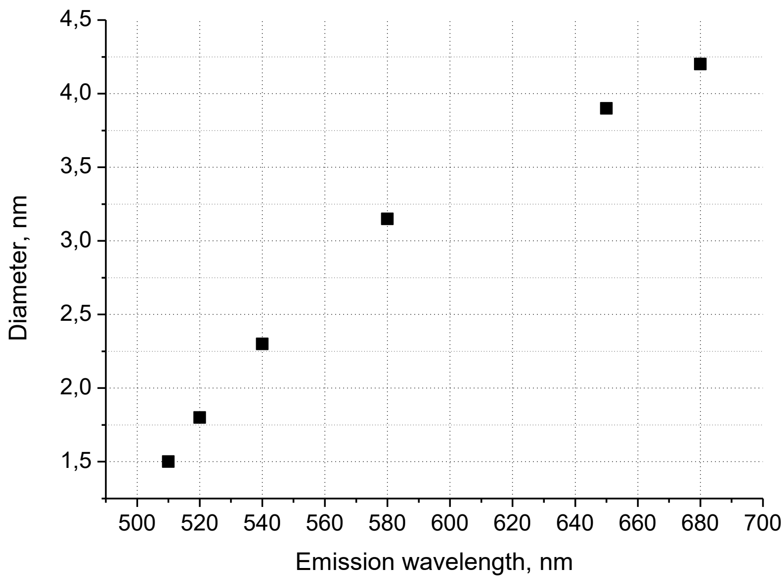
Aim:

Name: Date:

Sample #	Wavelength	Size of QD particles

Wavelength-color diagram

Wavelength-size graph for CdTe QDs (experimental data)



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