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Teaching Sulfur Compounds with Sunflowers

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ABSTRACT

The heteroatoms, such as sulfur atom, are taught to the pharmacy undergraduates in their first semester of the program. The knowledge on sulfur compounds is significant, since there are available in the structural composition of antibiotics, such as the penicillin, and among others, the amino acids, and proteins. Prior to the lectures on antibiotics and other biologically important molecules, these pharmacists-in-training (PIT) were invited to name chemical compounds of their interests. The object-oriented responses include examples of heterocyclic or sulfur-containing compounds, such as sulflowers. The PIT found out that the front view of the two-dimensional (2D) structure of sulflower, would resemble the bloom of a sunflower (botanically known as *Helianthus annuus*) or an eight-pointed star. The sulflower's molecular formula is $C_{16}S_8$ or $(C_2S)_8$, which allow the PIT to classify it as a form of carbon sulfide (CS_2). From their inspection, the substance is a highly symmetrical and planar structure, just like the disk-shaped sunflower heads. In addition, the front view of 2D structure of persulfurated coronene (PSC, $C_{24}S_{12}$), displays a unique sulfur-rich structure that consists of 12 sulfur atoms and 24 carbon atoms, arranged in a star pattern. The PIT's discussion would deepen into the atomic bonding, the geometry of the compound, and three-dimensional (3D) molecular arrangement. The information for both hydrocarbon and heterocyclic chemistry topics were successfully shared among the PIT, via such learning educational activity. The undergraduate research course in Year 3 of the pharmacy program could further include the laboratory projects on the extraction and chemical analysis of the sunflowers seed extractions. This would introduce PIT to the lessons on traditional herbal and medicinal practices, plus pharmacognosy. In addition to their practical uses, the sunflowers are also important in art and culture. In short, natural product resources like *Helianthus* plant species, could be chosen as an interesting and creative pharmaceutical teaching aid.

Keywords: drawing, pharmacy, sulfur, sunflower, teaching

1.0 INTRODUCTION

The sunflower (scientific name: *Helianthus annuus*) is categorised in the Asteraceae family. It is native to North and Central America (Guo *et al*. 2017). The plant is known for its large, bright yellow, disk-shaped flower heads, that can grow up to 30 cm in diameter, with hundreds of tiny individual little flowers arranged in a spiral pattern, while, black sunflowers appear black, having nearly dark petals, instead of the regular golden colour (Flower Show, 2024, Figure 1).

Figure 1. The bright, golden (left) and the black (right) sunflower heads (Flower Show, 2024), which consist of the ray floret (petals) and the disc florets (Plants of the World Online, 2025).

The sunflowers are grown for their ornamental value. The sunflower seeds are the part of the disc florets, which are consumed during snacking. Furthermore, they are used as birdseed and livestock feed. The seeds are also pressed to make cooking oil (Guo *et al*. 2017). In addition to their practical uses, sunflower heads are popular in bouquets and combined in floral arrangements. They bring inspirations in art and culture. They are symbols of happiness, loyalty, and spiritual significance in many cultures. In the art world, sunflowers have been featured prominently in the works of Vincent van Gogh, who painted a series of sunflower paintings in the late 1800s.

2.0 TEACHING SULFUR COMPOUNDS TO PHARMACY STUDENTS

The sulfur atom (symbol: S) is one of the heteroatoms in the periodic table of the elements. It is part of the syllabus for the first semester of the Bachelor of Pharmacy (Hons.) program. The knowledge of sulfurous compounds is significant, as it is present in the structural composition of antibiotics (Lteif & Eiland, 2019). Prior to the lectures on the biologically important molecules, the pharmacists-in-training (PIT) were invited to name chemical compounds of their interests. The object-oriented responses include the examples of heterocyclic or sulfur-containing compounds, such as sulflowers.

The PIT found that the front view of the two-dimensional (2D) structure of sulflower [formula: $C_{16}S_8$ or $(C_2S)_8$], would resemble the bloom of a sunflower or an eight-pointed star (Figure 2). The sunflower could be related to the teaching of sulfur compounds when studying the molecular design. Narratively, the atomic arrangement in the sulflower, mimic the sunflowers' shape. This information could be integrated in the understanding of the structural formation of organic and sulphurous molecules. In the sulflower, there are eight sulfur (S) atoms and sixteen carbon (C) atoms, connecting in a form of a sunflower-look-alike. The front view of 2D structure of sulflower could be retrieved via an open-source web-application (MolView, 2024).

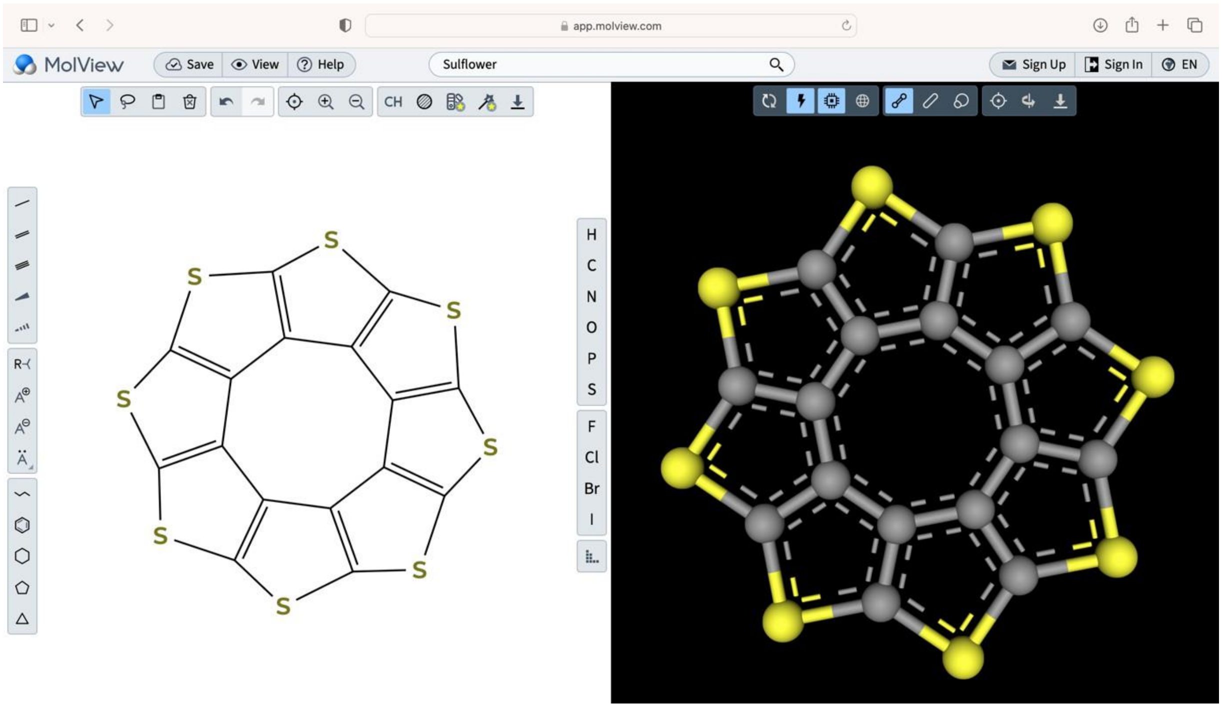


Figure 2: The sulflower's molecular formula is $C_{16}S_8$ or $(C_2S)_8$, which allows the student to classify it as a form of carbon sulfide (CS_2). The 2D structure can be sketched as a highly symmetrical planar structure (left). The 3D structure of the sulflower resembles the bloom of a sunflower or an eight-pointed star (right) (Chernichenko *et al*. 2006).

The essential molecular innovation by Chernichenko (2006) and co-researchers involved simultaneous treatment of a heterocyclic or sulfur-containing compound, with an excess of sulfur (S) atoms. Subsequent thermal decomposition of the crude poly-organosulfur molecules in vacuum, led to elimination of the excess of sulfur, through hydrogen sulfide (H_2S) and elemental S atoms. The synthesis and characterization of an unprecedented persulfurated coronene (PSC, formula: $C_{24}S_{12}$) with an all-sulfur terminated edge structure, was considered as the second-generation sulflower (Dong et al. 2017; Figure 3). The PSC is a member of the coronene family, which is a class of polycyclic aromatic hydrocarbons (PAHs) composed of fused benzene (C_6H_6) rings. PSC is a relatively new compound, and research on its properties and potential applications is ongoing. Its unique structure and properties make it an interesting subject of study for scientists in a variety of fields.

In the 2D structure of PSC, all hydrogen atoms in coronene are substituted with sulfur atoms. The PSC was generously provided to Jensen *et al*. (2019) for a collaborative project, funded by the European research and molecular innovation programme. This information for hydrocarbon lecture was shared among the PIT, via creative molecular drawings and learning activities. The 3D molecule of PSC has the unique sulfur-rich structure that consists of 12 sulfur atoms and 24 carbon atoms arranged in a pattern that is similar to a star (Figure 3). The interactive chemical structure of PSC can also be observed via PubChem, an open chemistry database (PubChem, 2025). The molecule can be displayed either as a ball and stick, sticks, wireframe or the space-filling models (Figure 4). The animated conformer of PSC would provide the rotational view of the planar molecule (PubChem, 2025). This representation can confirm that the structure is symmetrically aligned. It provides significant knowledge in materials science due to its electronic and optical properties. It can act as a semiconductor and studied for its potential in energy storage applications (Jensen *et al*. 2019).

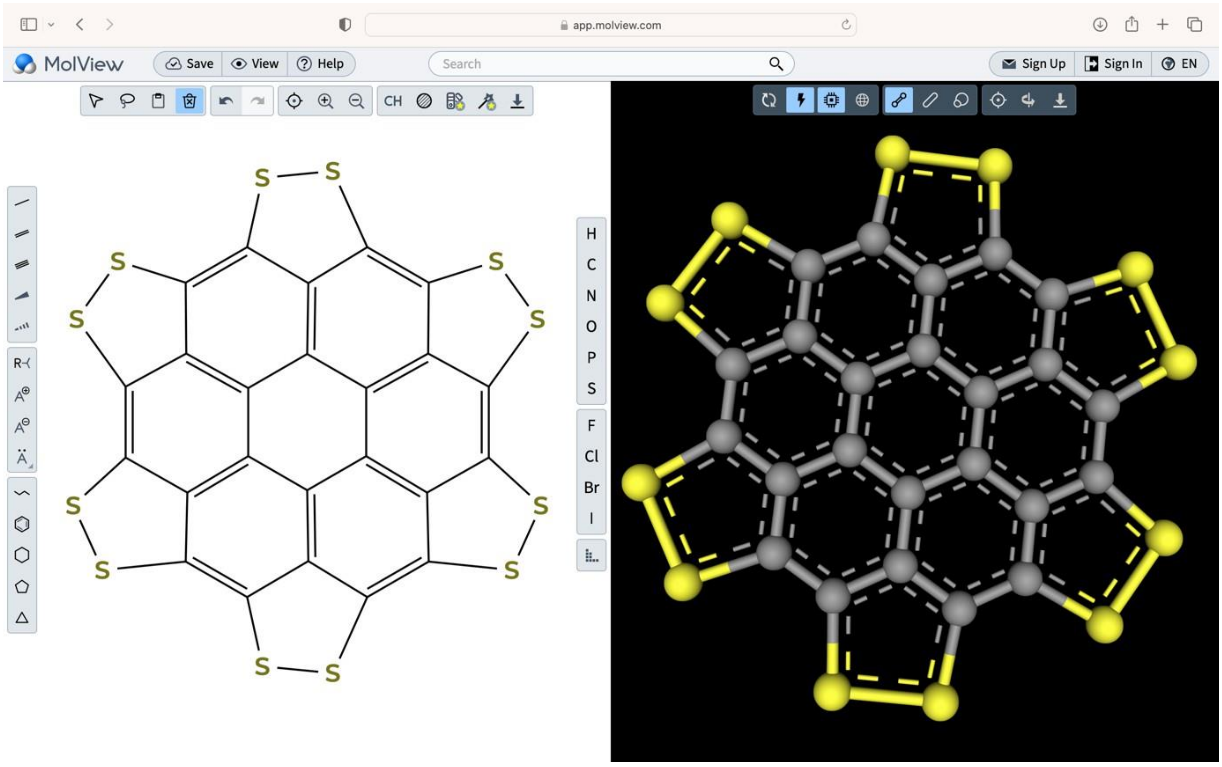
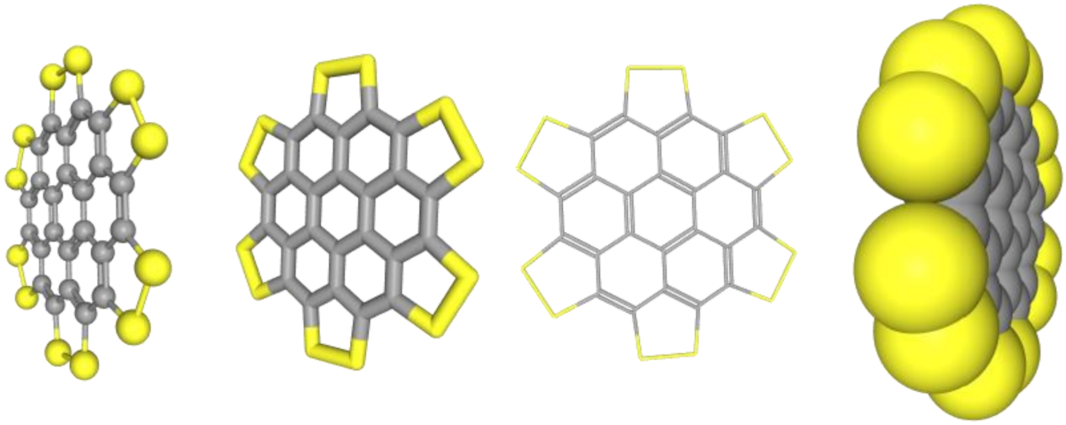


Figure 3. The front view of 2D structure of persulfurated coronene (PSC) can be sketched in Molview. It consists of 12 sulfur and 24 carbon atoms (left). The 3D structure of PSC is arranged in a pattern that resembles a star (right) (Jensen *et al*. 2019).



(a) (b) (c) (d)

Figure 4. The animation of rotating PSC planar molecule can be viewed either as a (a) ball and stick, (b) sticks, (c) wireframe or (d) the space-filling models (source: PubMed).

All four three-dimensional (3D) models of sulflower and persulfurated coronene (PSC) could represent the inflorescence or the sunflower head. The ball and stick model (Figure 4a) is the 3D reproduction of PSC where the atoms are represented by spheres of different colours, while the bonds appear as sticks between the spheres. Certain atoms are dedicated with different colours, for example, black or grey usually represent the carbon atom and white could act as the hydrogen atom. In the case of PSC, the yellow is meant for sulfur atom. The stick model (Figure 4b) represents the chemical bonds between the atoms. These bonds are visualized as lines in structural formulas. The grey lines represent the carbon atoms and the yellow lines act as the sulfur atoms. The wireframe model (Figure 4c) is the most classical model that uses wires to visualize the bonds and angles of the atoms in PSC. This model obviously shows the type of atoms in the molecule. The grey wires represent the carbon atoms and the yellow wires belong to the sulfur atoms. The distances between bonds and the angles associated with the atoms could also be interpreted. Finally, the space-filling model (Figure 4d) is a type of 3D molecular model where the atoms are represented by spheres. The sphere's radius is proportional to the atom's radius. The atoms of different chemical elements are represented by spheres of different colours. For PSC, the yellow spheres are for the sulfur atoms. Meanwhile, the grey spheres represent the carbon atoms. Here, the yellow spheres could also be seen as the outer part of the sunflower petals or the ray florets. In the meantime, the grey spheres could be observed as the disc floret of the sunflowers.

This specific educational method could be employed by using hands-on technique on the computational program. UiTM Library or Perpustakaan Tun Abdul Razak (PTAR) offered the web-based tool for the sketching and retrieving information on chemical compounds and data from published literatures, including journals and patents. The benefits of this approach would include providing training and digital skills to the young, unexperienced medicinal chemists who can predict the outcomes of various chemical reactions to a library of pharmaceutically active and safe compounds. All 3D models (Figure 4) could introduce various representation of structural molecules and how they could correspond to other objects in nature. The PIT's respond could be established when they further enrol to an upper level of practical year in their pharmacy program. It is anticipated that the PIT would both enjoy learning the chemistry of compounds and the anatomy of the sunflowers.

3.0 CONCLUSION

The names of the natural product compounds are usually given depending on the species of origin, be it a plant, a marine organism or a microbial species. In some cases, the names are given with reference to people, animals, music, foods or places. Many products also refer to countries, cities or specific places such as mountains, deserts, seas and oceans (Bailly, 2022). In this particular case, the name of sulflower are given with reference to the plant species of sunflower, which is made up of hundreds of little flowers that are symmetrically aligned. The students can appreciate and learn both art and the chemistry, by admiring the sunflowers, observing the star shaped objects, plus drawing the sulflower and persulfurated coronene (PSC), with online computerised graphic tools. The molecular structures are the examples of planar, rotationally symmetrical molecules, comprised purely of carbon (C) and sulfur (S) elements. The S atom is a constituent of the amino acids such as cystine, cysteine, methionine and glutathione. Therefore, it plays an important structural role in many proteins. It is also an essential nutrient for the production of a quality sunflowers seed oil (Swetha *et al*. 2022). At the faculty, the pharmacy students can also learn about sulphur compounds by attending formal lectures, reading the articles, sketching the structures themselves, comparing the variability in the compositions and arrangements of the compounds, plus discussing the geometry of the molecule or drugs in a group activity during poster presentation. The undergraduates can study both 2D and 3D representatives of chemicals, involving the atomic bonding.

In summary, the significance of the connection between sunflowers and sulfur compounds could be observed. It lies in how the compounds, which are substances formed by two or more natural elements, could be chemically bonded. It resembles the physical objects that human could see and interact with. The students can appreciate the display and illustration of the sunflowers and relate them with the occurrence of sulfurous compounds, such as the sulflower and PSC.

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Flower Show[@TheFlowerShow](July 2, 2024) Bees are in love with sunflower. [Image attached] [Tweet]. X. https://x.com/TheFlowerShow/status/1808077342062858286.

Flower Show[@TheFlowerShow](Jun 7, 2024) She grows on love ! Black sunflower for my favorite girls ! [Image attached] [Tweet]. X. https://x.com/theflowershow/status/1798816570543874095?s=43&t=elGXcESf-kAB1nUTmsEKWQ.

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