Commentary

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Sulfur's Role in Natural Product Biosynthesis: Mechanisms and Biotechnological Applications

Michael Samuel*

Department of Chemistry, University of California San Diego, California, USA

Corresponding author: Michael Samuel, Department of Chemistry, University of California San Diego, California, USA, E-mail: samichae@cal.edu

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Description

One of the most abundant elements on Earth, sulfur is essential to biological and industrial processes. With approximately 80 million metric tons of elemental sulfur being mined in 2022, sulfuric acid, which is derived from sulfur, is the most widely produced chemical worldwide. The recognizable sulfur piles on the Vancouver waterfront are illustrative of the significance of these enormous quantities, which highlight its significance in a variety of industrial applications. Sulfur is needed by all living things in the biological world. It is integrated into fundamental biomolecules, including proteins, nutrients and metabolites like taurine and lipoic corrosive. In spite of the fact that selenium, sulfur's heavier partner, is less plentiful, it is as yet basic for the capability of explicit nucleic acids and redox proteins. Intricate mechanisms for incorporating sulfur, which can be found in oxidation states ranging from -2 to +6, into a wide variety of bioactive natural products have been developed throughout life's evolution. Sulfate, thiol, thioether, persulfide and thiocarboxylate are some of the oxidation states at which sulfur from organic and inorganic sources can be incorporated into natural products. Other oxidation states include persulfide. Many organisms use a reductive pathway to take in sulfate and turn it into Sulfide (S^{2-}).

Cysteine synthase

The cysteine synthase complex then transforms this sulfide into cysteine. Coenzyme A, glutathione, methionine and S-adenosylmethionine are all organosulfur metabolites that can all provide sulfur for the biosynthesis of natural products. Cysteine is a precursor for these organosulfur metabolites. Additionally, cysteine desulfurases can desulfurize cysteine to produce protein-bound cysteine persulfide, a vital sulfur donor in sulfur metabolism and natural product biosynthesis. The persulfide sulfur can be moved to sulfur transporter proteins, framing a thiocarboxylate end, which works with the consolidation of sulfur into cofactors like thiamine and molybdopterin, as well as other normal items. Then again, in a non-reductive pathway, sulfate can be switched over completely to phosphoadenosine 5′-Phosphosulfate (PAPS), which moves the SO_3-gathering to-goodness or $-NH_2$ bunches in steroids, lipids, oligosaccharides and other normal items. Natural products, such as SO_2 and inorganic sulfide ions, can also contain sulfur directly. The enzymes that catalyze these transformations and the source of sulfur both have a significant impact on the variety of mechanisms by which sulfur is incorporated into natural products. Understanding the enzyme-catalyzed formation and cleavage of Carbon-Sulfur (C-S) and Carbon-Selenium (C-Se) bonds in natural product biosynthesis has significantly improved over the past few years.

Natural products

Natural products containing sulfur, which frequently have distinctive structural characteristics and potent bioactivities, require these transformations in order to be produced. The most recent research has shed light on the intricate mechanisms organisms use to incorporate sulfur into complex molecules by revealing novel enzymes and pathways involved in these processes. The discovery of new enzyme families that catalyze the formation of C-S and C-Se bonds in a variety of natural products is one example of a recent breakthrough. These enzymes frequently employ sophisticated catalytic mechanisms and have remarkable substrate specificity. For instance, some enzymes cleave or form C-S bonds using radical-based mechanisms, while others use more conventional nucleophilic substitution reactions. Sulfur's versatility in natural product biosynthesis is highlighted by the variety of these enzymatic strategies. In sulfur plays a variety of roles in natural product biosynthesis, all of which involve a wide range of enzymatic processes and oxidation states. The new advances in understanding these cycles develop our insight into sulfur digestion as well as open up new roads for the biotechnological creation of sulfur-containing compounds. We can anticipate additional innovations in the use of sulfur for industrial and therapeutic purposes as research continues to reveal the complexities of its incorporation into natural products.