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Natural occurrence, biological activity and formation of some molecules which changed human life

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Abstract

Some small molecules in nature show biological activity, are medicinally important and were used at least a few hundred years ago. These compounds are commonly used to treat fever, acute pain, and inflammation as anticancer, antibacterial, anticonvulsive, anti-HIV, antidiabetic, anti-inflammatory, analgesic, anti-asthma, and antipyretic medications. Some of them are also used as scents and perfumes. Due to the versatile character of these molecules, they are very important and essential in our daily life. These molecules have completely changed our lifestyle. Some molecules are used more than 3,500 years ago and are still used. These molecules are also very useful and popular in our modern society. This review aims to explain the natural occurrence, biological activity, medicinal properties, and synthesis in the laboratory.

Keywords: Natural occurrence, biological activity and medicinal properties and synthesis.

Introduction

Science's destiny is to be deeply involved with society. For thousands of years, science has provided benefits to humanity. Various natural organic compounds have been recorded of useful levels or biological activity, which has encouraged chemists concerning procedures for preparing these compounds. We can synthesise high-value chemicals from abundant natural resources like oil, coal, and biomass using Biological Science and Organic Synthesis. Molecules are composed of some atoms connected under a fixed structural feature and rules. It has only one configuration and can have several conformations. Organic molecules with these three-dimensional fixed structures may have interesting biological and medicinal properties. We can design and create molecules with biological and medicinal properties using our knowledge. Throughout human history, small organic compounds have cured tens of millions of people of serious diseases and changed the quality of life. Synthesis of biologically active compounds will always be at the heart of medicinal chemistry. Adrenaline, for example, is a human hormone, and we know a little about its composition. It is created under stressful situations and raises our blood pressure and pulse rate, preparing us for fight or flight (Gedeborg et al., 1989). Adrenaline is intensely interesting to an organic chemist because of its remarkable biological activity. Modern society is dependent on organic synthesis for medicine and various purposes, e.g., there are so many beautiful organic compounds used as perfume and changed the human lifestyle.

Urea:

The main natural source of urea (Fig. 1) is human urine. Hilaire M. Rouelle first discovered and isolated urea from human urine in 1773. Urea has the ability to form several stable hydrogen bonds with protein and

receptor targets, resulting in unique therapeutic benefits, biological activity, and pharmacological properties. Urea functionalities are used to increase medication potency and selectivity and improve pharmacological features in the synthesis of anticancer, antibacterial, anticonvulsive, anti-HIV, antidiabetic, and other pharmaceutical compounds (Gallou et al., 2007 ; Regan et al., 2002). Heterocyclic urea derivatives play an important part in anticancer drugs due to their potent inhibitory impact.

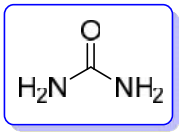
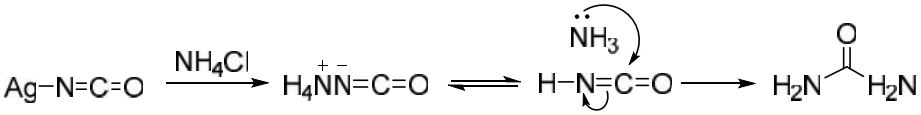


Figure 1: Structure of Urea.

There are many methods for the preparation of urea. The first synthesis of urea by German chemist Fredrich Wöhler in 1828 heralded the beginning of organic chemistry (Wöhler et al., 1828; Ramberg, 2000). In 1828, Wöhler treated an inorganic substance, silver isocyanate, with another inorganic substance, ammonium chloride and found an organic compound, urea (Scheme 1). He then first established that it was possible to make 'organic compounds' without the involvement of any living system.



Scheme 1: Formation of Urea.

Saccharin:

Saccharin (Fig. 2) is a non-fattening artificial sweetening agent and does not occur naturally. Saccharin was not a carbohydrate (Schulze et al., 1997) produced on an industrial scale (1887) shortly after its discovery as the first sweetening agent. During an experiment on the oxidation of o-toluene sulfonamide, Constantin Fahlberg, a research fellow of Ira Ramsen, discovered saccharin by accident in 1878 (Ellis, 1995), isolated from coal tar and published in 1879 (Fahlberg & Remsen, 1879).

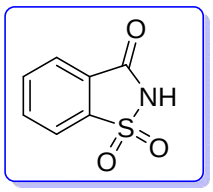
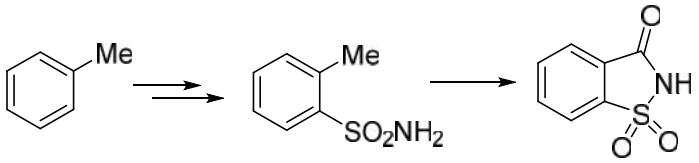


Figure 2: Structure of Saccharin.

The coal tar chemistry then gave birth to a fledgling pharmaceutical industry. Saccharin is a non-toxic sweetener with a sweetening strength over 300 times that of sugar. Its antibacterial characteristics help prevent the aberrant fermentative alterations that occur in diabetic patients' stomachs. It is reported (Malik et al., 1984) that saccharin is potentially useful as an antidote for metal poisoning. Because saccharin is mildly acidic, it has been reported (Baran et al., 2006) that it can be used in pharmaceutical chemistry to generate a salt that improves the solubility of some pharmaceuticals (Bhatt et al., 2005).

Saccharin has an aromatic ring with a cyclic imide system that contains acylated nitrogen on one side by a sulfonic acid and carboxylated nitrogen on the other side by a carboxylic acid. The outline of the synthesis of saccharin is given below (Scheme 2).



Scheme 2: Preparation of Saccharin.

Aspirin:

The natural source of aspirin (Fig. 3) is the bark of the Willow tree. Aspirin was introduced more than 3,500 years ago, and soon after its introduction, ancient Egyptian physicians advocated salicin as a remedy for back pains. Salicin is derived from Salicaceae, the Latin name for the willow family. One thousand years later, salicin became familiar to all doctors, and they prescribed willow bark extract for pain, fever and childbirth.

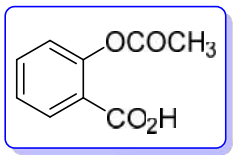
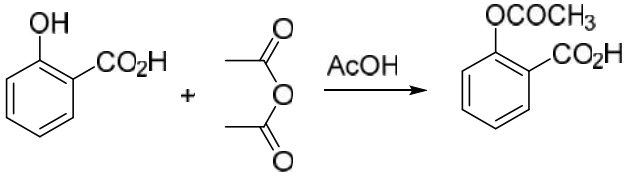


Figure 3: Structure of Aspirin.

Felix Hoffmann first synthesized aspirin in 1897, suitable for therapeutic use. Hoffmann described that aspirin was free from side effects. But, of course, it has some side effects used for long periods, including some gut irritation. Furthermore, because aspirin has negative side effects in adolescents, it is no longer recommended for the treatment of fever in children and teenagers.

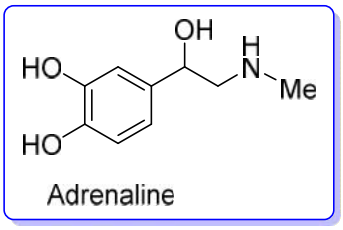
The reaction between salicylic acid and acetic anhydride (Scheme 3) yields aspirin's widely used pain reliever in good yields.



Scheme 3: Synthesis of Aspirin.

Adrenaline Salbutamol:

Adrenaline (Fig. 4) is a hormone produced by the adrenal glands that work in tandem with noradrenaline to prepare the body for 'fight or flight' situations. Adrenaline is prescribed as a medicine to treat the symptoms of cardiac arrest, hypotension related to Septic Shock, allergic reaction, symptomatic bradycardia and Mydriasis. Adrenalin is prescribed alone or with other supporting medicines.



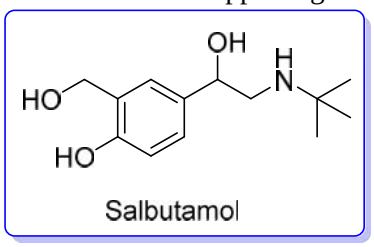
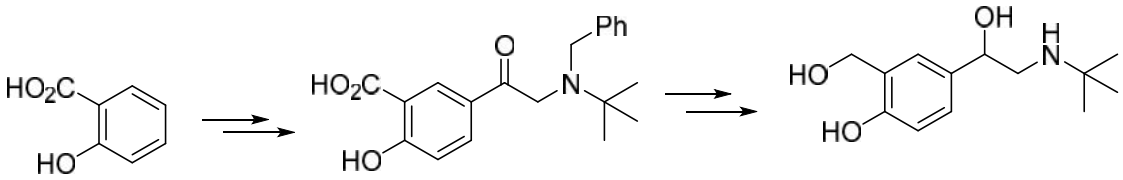


Figure 4: Structure of Adrenaline & Figure 5: Structure of Salbutamol

Some common side effects of Adrenalin include pale skin, nausea, vomiting, fast or pounding heartbeats, breathing problems, sweating, dizziness, throbbing headache, feeling nervous, weakness or tremors, anxiety and fear. Asthma is a serious and indiscriminate disease, attacking adults and children with equal ferocity. In 2000, the World Health Organization (WHO) estimated that 100-150 million people worldwide had asthma, with an annual death toll of more than 180,000 individuals. The harmful side effects of adrenaline were avoided by adding an extra carbon atom, resulting in salbutamol (Fig. 5). Salbutamol mimics the hormone adrenaline's action by dilating the lungs' air channels, relieving the tightness that is characteristic of asthma. Salbutamol's t-butyl group boosts the drug's stability, allowing it to have a longer-lasting impact.

The outline of the synthesis of salbutamol is given below (Scheme 4).



Scheme 4: Synthesis of Salbutamol.

Paracetamol:

Paracetamol (Fig. 6) has been very popular for many years. A safe analgesic compound has become increasingly popular as a substitute for aspirin, but its overdose is dangerous if used properly. The patient often appears to be recovering, only to succumb to liver failure later.

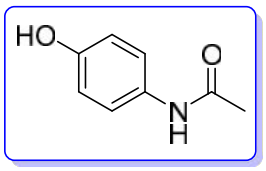
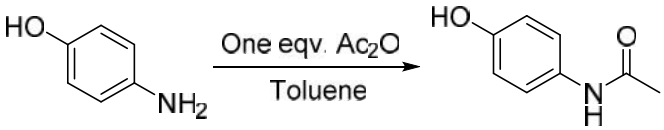


Figure 6: Structure of Paracetamol

Paracetamol is converted into an oxidised molecule that degrades glutathione, which is an issue. On both nitrogen and oxygen, 4-aminophenol could react with acetic anhydride to form a molecule having an amide and an ester functional group. This occurs when toluene is heated with too much acetic anhydride (Scheme 5).



Scheme 5: Preparation of Paracetamol.

Brufen (ibuprofen):

Ibuprofen (Fig. 7) is a propionic acid derivative introduced in 1969 as a non-steroidal anti-inflammatory, analgesic, and antipyretic drug to relieve inflammation, acute pain, and fever symptoms. It was first introduced in 1969 and is known as a non-steroidal anti-inflammatory, analgesic, and antipyretic drug to relieve symptoms of inflammation, acute pain, and fever (Rainsford, 2009).

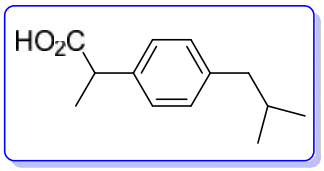
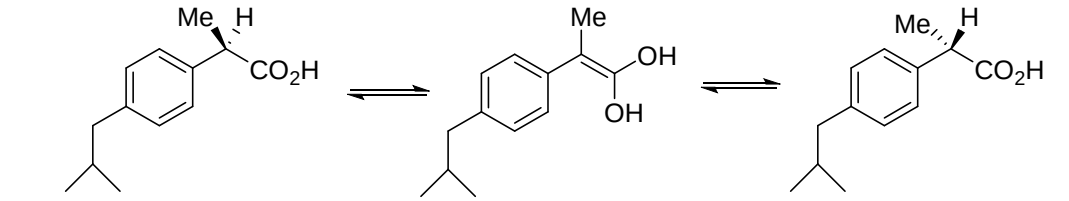


Figure 7: Structure of Ibuprofen.

It is a well-known non-prescription medication that is extensively utilised (Buser et al., 1999). Furthermore, ibuprofen is said to be better for joint and muscular pain than other pain relievers, and it has long been used to treat arthritis. Ibuprofen has some common side effects, including gastric discomfort, the renal, the central nervous system, nausea, and vomiting (Cheng et al., 1994) though less than aspirin (Tripathi, 2003). Ibuprofen has only one enantiomer that relieves pain, yet it is given as a racemate. The body takes care of the remainder, analysing the molecule and racemizing it.

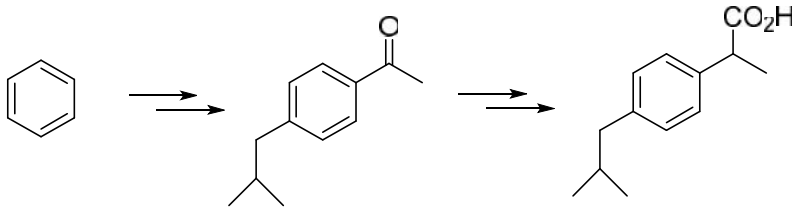


the biologically inactive enantiomer of ibuprofen

flat achiral enol

the biologically active enantiomer of ibuprofen

The outline of the synthesis of ibuprofen is given below (Scheme 6).



Scheme 6: Preparation of Ibuprofen.

Camphor:

Camphor ($C_{10}H_{16}O$), a bicyclic ketone found naturally in the wood of the camphor tree (Cinnamomum camphora) and obtained through distillation or chemical transformation of other natural products such as turpentine, is a bicyclic ketone native to Taiwan, China, Japan and the Malay Archipelago (Noller, 1965). The active substance (1R)-(+)-camphor, i.e., natural camphor, is obtained by distilling the essential oil from the wood (Van et al., 2009).

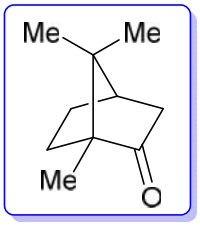
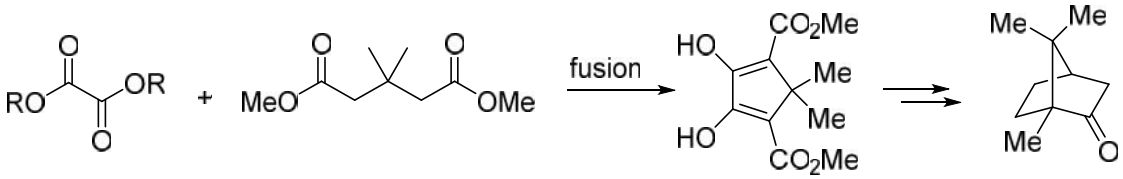


Figure 8: Structure of Camphor.

The ancient Chinese collected it from its natural sources for medicinal purposes, as recounted in the thirteenth century by the great explorer of the orient Marco Polo. Since antiquity, camphor has been employed in a variety of purposes, including food flavourings, fumigants, fragrances, cosmetics, home cleaners, and topically administered analgesics (Chen et al., 2013). Camphor has been discovered to have a variety of biological actions in the medical area, including antiviral, antibacterial, antitussive, and analgesic properties (Sokolova et al., 2013; Juteau et al., 2002 ; Viljoen et al., 2003).

The Chinese employed camphor as a circulatory stimulant and analeptic, while the Japanese used it in torch-light material and added small quantities to pyrotechnics to make them brighter. Camphor has a long history of significance due to its broad and diversified usage in the East (Hattori, 2001). Camphor was employed as a fumigant during epidemics of cholera, smallpox, and the Black Death, which occurred in Europe in the 14th century. The pandemic that was known as the Black Death was responsible for killing millions of people across Europe. Before the coffins were covered, the bodies were perfumed with rosewater and camphor, both of which are ingredients in perfume (Donkin, 1999). Camphor is a fragrant resin that is traditionally used in religious ceremonies in India. Unlike other types of aromatic smoke, camphor vapours do not irritate the eyes in the same way that other types of smoke can (Kumar et al., 2003). Camphor is commonly used in homes as an insect repellent, a plasticizer, and an intermediate in aroma chemicals synthesis. It is also widely used in the cosmetics industry as a fragrance, flavouring food additive, and preservative in confectionery goods. Camphor has also been used extensively in the food and beverage industry (Gomes et al., 1998). In addition to this, it has been reported (Philpott, 1929) that intramuscular injections of camphor have been used to alleviate the pain that is caused by breast engorgement. On the other hand, ingestion of camphor results in a hazardous substance that can cause convulsions, confusion, irritability, and neuromuscular hyperactivity. 50–500 mg per kilogramme of body weight is the human fatal dosage range (Liebelt et al., 1993). Camphor has been used for various purposes in the home, ranging from preventing the wood from rotting and warding off insects to treating many disorders, such as rheumatoid arthritis, sepsis, and hysteria. Camphor has been around for centuries.

The outline of the synthesis of camphor is given below (Scheme 7).



Scheme 7: Formation of Camphor.

Terpineol:

α-Terpineol, often known as Fig. 9, is a volatile monoterpenoid alcohol that is a component of the essential oils of several different plant species (Dagne et al., 2000; Golshani et al., 2004; Raina et al., 2004).

The anticonvulsant effect of many essential oils can be attributed to the presence of terpenes, which are the primary ingredients (de Sousa et al., 2007; Almeida et al., 2003).

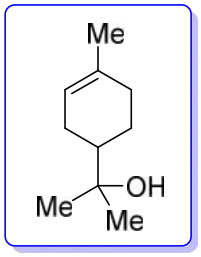
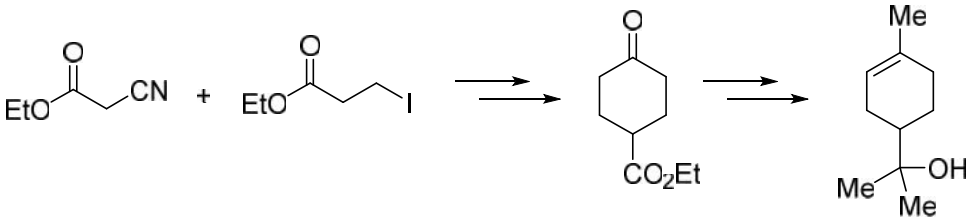


Figure 9: Structure of Terpineol.

In the perfumery, cosmetics, and soap sectors, α-terpineol is commonly used. It's also utilised in household items as a scenting ingredient (e.g., disinfectant sprays) (Craveiro et al., 1981). Pine trees have been revered for their wood, bark, and resin by ancient cultures from Mesopotamia to Egypt to Greece. They discovered a large number of applications.

Terpineol is an unsaturated, light oil with a strong aroma that has been used in paints, disinfectants, medications, and materials for religious ceremonies and perfumes from the dawn of time. Perfumes have been appreciated and experimented with by ancestors for thousands of years (Morris, 1999).

Finally, terpineol ushered in a revolution in perfume chemistry. However, the booming chemical industry of Germany became a centre for perfume manufacturing as chemistry evolved and organic synthesis was born in the nineteenth century. France, on the other hand, became a centre for perfume combining. The following is a diagram showing the terpineol synthesis (Scheme 8).



Scheme 8: Preparation of Terpineol.

Tropinone:

Tropinone (Fig. 10) was one of Sir Robert Robinson's most spectacular complete syntheses, released in 1917. (Robinson, 1917). Tropinone is a significant member of the tropane alkaloid class of natural products that has been identified from a variety of Solanaceae plants, such as Atropa belladonna and Datura.

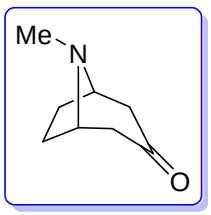
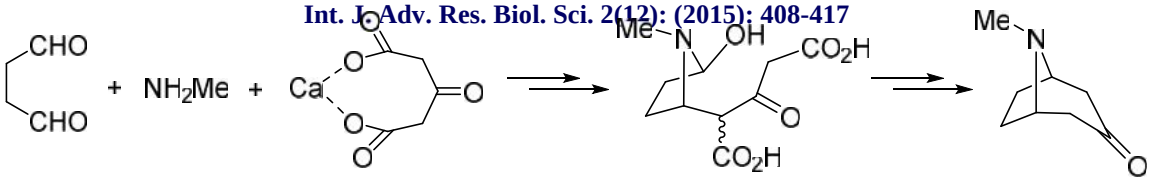


Figure 10: Structure of Tropinone.

Tropinone was a key synthetic target since it could be used to generate a variety of different congeners of this class of alkaloids, the most well-known of which is Cocaine. This chemical's stimulating and analgesic characteristics piqued people's interest (Nicolaou, 2006). The outline of the synthesis of tropinone is given below (Scheme 9).



Scheme 9: Synthesis of Tropinone.

Quinine:

By modern standards quinine (Fig. 11) is a small and fairly simple molecule that has a most colourful biography, yet it has played a pivotal medicinal role in human society for hundreds of years. Since the identification and purification of quinine from the bark of Cinchona trees in 1820, other quinine derivatives have been isolated from natural sources (Heeb et al., 2011 ; Greenwood, 1992).

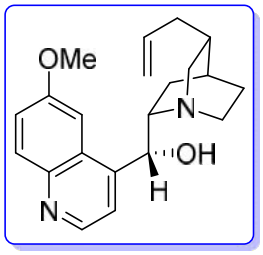
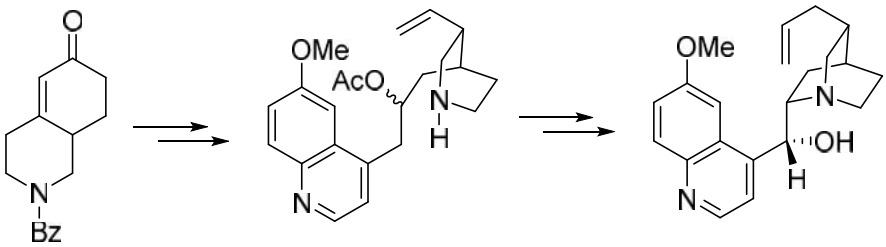


Figure 11: Structure of Quinine.

It has been used to treat the deadly fevers associated with malaria for nearly four hundred years. It is referred to in both the ancient Indian Vedic writings and in the prose of the Hipocrates from 5,000 and 2,500 years ago, respectively. The brilliant chemist Robert B. Woodward and his student, Williamvon, Eggers Doering, formally synthesized quinine in 1944. Later, Vladimir Prelog established the stereochemistry of quinine and won the Nobel prize in chemistry in 1975. There are several methods for preparing quinine and quinine derivatives (Weinreb, 2001 ; Nicolaou, 2003).

The outline of the preparation of quinine is given below (Scheme 10).



Scheme 10: Formation of Quinine.

Conclusion

Chemical and biological research on these molecules has continued, resulting in new treatments and the creation of exquisite chemical synthesis techniques and tactics. The use and design of these natural compounds have led to treatments for a wide range of diseases. In addition, many of these molecules are used in medicine, scent, and perfumes, changing the human lifestyle.

Acknowledgments

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