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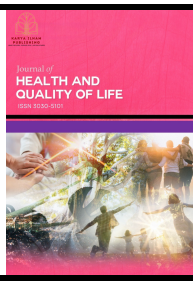

Characterization of Analgesics: A Preliminary Review

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ABSTRACT

The purposes of this review are to introduce the type of analgesics and to investigate the use of Fourier Transform Infrared Spectroscopy (FTIR), Ultraviolet-Visible Spectroscopy (UV-VIS), and Scanning Electron Microscopy (SEM) in the identification of analgesics properties and element composition for medical proposes. The review covers the principle and capabilities of these analytical techniques and their application in pharmaceutical analysis. It also highlights significant studies that used FTIR, UV-VIS, and SEM to examine the atomic and molecular of analgesics, allowing for their characterization and quality assessment.

1. Analgesics in Medical Applications

NSAIDs are a class of non-opioid analgesics often used to treat acute pain [1] and some of the most influential and established medications in use today. By preventing the production of prostaglandins, NSAIDs help treat pain, fever, and inflammation [2]. NSAIDs are physically varied and have different pharmacokinetic and pharmacological features, but they all have the same method of action [2]. Analgesics are often used to treat pain caused by dental treatments such as tooth extractions, root canals, and gum surgery to guarantee patient comfort before and after procedures [3]. It also commonly used in emergency medicine to provide quick pain relief to patients suffering from catastrophic injuries, fractures, burns, or other situations. They can aid in stabilizing the patient, reducing distress, and facilitating future diagnostic and therapeutic procedures [4].

1.1 Acetaminophen (Paracetamol)

Paracetamol (Acetaminophen) was initially synthesized from its precursor phenacetin in 1878. Now, it is the most used medicine in the world that has a long history of usage in acute and chronic pain. It is presently the most widely used analgesic globally and the first rug on the World Health Organization (WHO) analgesics ladder for treating cancer pain [5].

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N-acylated aromatic amines (those with the acyl group attached to the nitrogen atom), such as phenacetin and acetaminophen, are non-prescription analgesics and antipyretics. Acetaminophen (paracetamol) or N-(4-hydroxyphenyl) etamine (IUPAC) is an antipyretic non-opioid analgesic with the chemical formula $C_8H_9NO_2$ and a mass of 151.18 g / mol [6]. This medication is the active ingredient in a range of oral medicines in tablet and syrup forms, usually for kids. It is utilized globally due to its superior efficiency and tolerance, reduced adverse effects and toxicity, and lower toxicity than other chemicals [7].

1.2 Aspirin

Acetylsalicylic acid (ASA), commonly known under its common name aspirin, exhibits both cardioprotective and anti-inflammatory properties, thus being of particular interest and importance as a nonsteroidal drug and NSAID. Aspirin became one of the most significant pharmaceutical achievements of the twentieth century to treat diseases and cancer chemoprevention [8].

According to IUPAC, Aspirin is 2–Acetoxy benzoic acid and has a planar molecular shape and a molecular mass of 180.159 g / mol. Molecular formula $C_9H_7O_4$. The aspirin molecule is an interaction product from a buffer and salicylic acid (SA). It is an irreversible inhibitor of platelet aggregation. However, its activity is lost following first-pass deacetylation to SA By adding a buffer, Aspirin is created and becomes a more tolerable chemical [9].

1.3 Ibuprofen

Ibuprofen is an NSAID medicine commonly used to treat pain and inflammation in various conditions by inhibiting cyclooxygenases. It is commonly used to treat mild to moderate pain and inflammation in arthritis, primary dysmenorrhea, headache, and other conditions. It is also a significant drug on the World Health Organization's Essential Drugs List and is available over the counter in most regions [10].

Ibuprofen, a 2-propionic acid derivative which a 4-(2-methyl propyl) phenyl group, substitutes for one of the hydrogens at position 2 and NSAIDS medicine. The molecular formula is $C_{13}H_{18}O_2$ with a molecular weight of 206.29 g / mol [11]. It was discovered by the British Boots Group's research division in the 1960s. It is a solid anti-inflammatory analgesic used to treat pain with a peripheral effect that functions by inhibiting COX-1 and COX-2 in a balanced and reversible manner. This medication is the active ingredient in several oral medicines in tablet, gel pellet, and syrup forms utilized globally due to their superior efficiency and tolerance and lesser adverse effects and toxicity than other compounds [12].

2. Mechanism of NSAIDS

NSAIDS are a pharmaceutical type often used as a pain reliever, anti-inflammatory agent, and fever reducer. NSAIDs work by inhibiting the enzyme cyclooxygenase (COX), which is essential in creating prostaglandins, which are chemical messengers implicated in pain, inflammation, and fever [13]. Cyclooxygenase has two isoforms: COX-1 and COX-2. COX-1 is constitutively expressed in many tissues and is engaged in various physiological tasks such as stomach lining maintenance, boosting renal blood flow, and assisting platelet aggregation. COX-2, on the other hand, is an inducible enzyme related to inflammation and discomfort.

The mechanism of action of NSAIDs is to inhibit both COX-1 and COX-2 enzymes, albeit some NSAIDs favour one isoform over the other. NSAIDs suppress the formation of prostaglandins, which are responsible for increasing inflammation, sensitizing pain receptors, and producing fever by inhibiting COX enzymes [14]. NSAIDS have numerous impacts by lowering prostaglandin production, including relieving pain by lowering the generation of prostaglandins, which are sensitive to pain receptors. This assists in reducing pain perception and providing relief. Next, it blocks prostaglandin formation to diminish inflammation, including the associated redness, swelling, and heat [15]. Lastly, it can lower fever by blocking the formation of prostaglandin, which contributes to body temperature elevation.

3. Analytical Techniques in Pharmaceutical analysis

Several previous studies, uses analytical techniques to examine the matter and energy underlying the properties and substance of selected analgesics (paracetamol, Aspirin, and Ibuprofen). The drug development process begins with the invention of a drug molecule that has demonstrated therapeutic value in combating, controlling, preventing, or curing diseases. The synthesis and characterization of such compounds, active pharmaceutical ingredients (APIs), and their analysis to generate preliminary safety and therapeutic efficacy data are required before identifying drug candidates for further extensive investigations [16].

3.1 Fourier Transform Infrared Spectroscopy (FTIR)

Fourier Transform Infrared Spectroscopy (FTIR) is a helpful technique for determining the presence of specific functional groups in an organic molecule. The vibration frequencies of functional groups are unique to that functional group. These vibration frequencies are in the infrared (IR) band [17].

As a result, transmitting an infrared signal through the organic complex causes the functional groups to vibrate at different frequencies. In other words, an infrared signal that passes through an organic compound will be absorbed at these specific frequencies, resulting in a distinct spectrum [18]. The wavelength scale is calibrated, and the measurement is set. Aligned the interferometer, the sample compartment components, and the detector element to correctly focused on the sample and resulting a proper signal.

Table 1
Table of spectral and wavelength range of paracetamol

Spectral and wavelength range of paracetamol		
Mid-infrared (MIR)	Range: 4000 to 400 cm^{-1}	Range: $2.5 - 25\ \mu m$
Fingerprints region	Range: 1800 to 400 cm^{-1}	Range: $5.6 - 20\ \mu m$
Hydrogen bonding region	Range: 3800 to 2800 cm^{-1}	Range: $2.6 - 3.6\ \mu m$
Carbonyl region	Range: 1800 to 1600 cm^{-1}	Range: $5.6 - 6.3\ \mu m$
O – H stretching region	Range: 3700 to 3000 cm^{-1}	Range: $2.7 - 3.3\ \mu m$

Table 2
Table of spectral and wavelength range of Aspirin

Spectral and wavelength range of Aspirin		
Mid-infrared (MIR)	Range: 4000 to 400 cm^{-1}	Range: $2.5 - 25\ \mu m$
Fingerprints region	Range: 1800 to 500 cm^{-1}	Range: $5.6 - 20\ \mu m$
Aromatic region	Range: 1600 to 900 cm^{-1}	Range: $6.3 - 11.1\ \mu m$
Carbonyl region	Range: 1800 to 1600 cm^{-1}	Range: $5.6 - 6.3\ \mu m$
O – H stretching region	Range: 3700 to 3000 cm^{-1}	Range: $2.7 - 3.3\ \mu m$

Table 3
Table of spectral and wavelength range of Ibuprofen

Spectral and wavelength range of Ibuprofen		
Mid-infrared (MIR)	Range: 4000 to 400 cm^{-1}	Range: $2.5 - 25\ \mu m$
Fingerprints region	Range: 1800 to 500 cm^{-1}	Range: $5.6 - 20\ \mu m$
Aromatic region	Range: 1600 to 900 cm^{-1}	Range: $6.3 - 11.1\ \mu m$
Carbonyl region	Range: 1800 to 1600 cm^{-1}	Range: $5.6 - 6.3\ \mu m$
O – H stretching region	Range: 3700 to 3000 cm^{-1}	Range: $2.7 - 3.3\ \mu m$

3.2 Ultraviolet-Visible Spectroscopy (UV – VIS)

UV-VIS spectroscopy can provide helpful information on analgesic drug absorption properties. An analgesic's UV – VIS absorption spectra can be used to identify features such as the conjugated systems and chromophores. These features contribute to the absorption of specific light wavelengths and can aid in the identification and discrimination of various analgesic substances [19]. UV – VIS spectroscopy can measure the absorbed energy corresponding to a given wavelength or energy of light. Furthermore, it can examine a molecule's electrical structure and properties by analysing the absorption spectrum, which includes the presence of conjugated systems and chromophores.

3.3 Scanning Electron Microscopy (SEM)

The scanning electron microscope (SEM) allows for thorough imaging and research of material surface topography and morphology. It creates high-resolution three-dimensional images of surfaces that highlight surface roughness, grain boundaries, defects, and surface coatings. This data can be used to understand material structural properties better, investigate surface phenomena, and optimize material performance.

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