STM JOURNALS

Research & Reviews: A Journal of
Drug Design & Discovery

ISSN: 2349-9036
Volume 13, Issue 1, 2026
January–April
DOI (Journal): 10.37591/RRJoDDD

https://journals.stmjournals.com/rrjoddd

Review RRJoDDD

Organic Compounds as Anti-inflammatory Agents, Natural and Synthetic

Khalid M. Darwish[1,*], Ehab El-Hawary[2]

Abstract

Inflammation diseases still threaten humanity everywhere. For which there is always a continuous demand for immediate medication, the so-called anti-inflammatory drug. Anti-inflammatory organic compounds are either of natural origin or synthetic. Many drugs represent the main constituent of plants. Turmeric, ginger, garlic, spinach, broccoli, ginseng, blueberries, clove, Aloe Vera and pineapple all are plants almost rich in anti-oxidant and flavonoids that reduce inflammation. Researchers still have spent decades of years exploring compounds that are known for their anti-inflammatory effect and hence inventing similar synthetic analogs, spending billions of dollars for research. Nowadays, artificial intelligence (AI) is taking part in the invention of new drugs in a comparatively short time and with lower price. Of course, there are plenty of synthetic drugs which can not be covered in this article but we will focus our attention on choosing the most common anti-inflammatory drugs used in Libya such as ibuprofen, diclofenac, and ketoprofen in addition to the other frequently used drugs such as aspirin and naproxen. The use of these along with other non-steroidal anti-inflammatory drugs (NSAIDs) is widespread, although expensive, for conditions like headaches, muscle injuries, and dental pain. We will also show their chemical structure, the method of their synthesis, their pharmaceutical importance, and their side effects.

Keywords: Anti-inflammatory Drug, Artificial Intelligence, Headache, Injuries, Turmeric

INTRODUCTION

As a major natural process of defense, inflammation occurs in response to tissue injury, cell death, cancer, ischemia, and degeneration. Plant natural products possess the ability to neutralize inflammatory reactions [1]. Recent research has highlighted that coumarin possesses anti-inflammatory properties, positioning it as a promising candidate for treating inflammatory disorders such as rheumatoid arthritis, asthma, and inflammatory bowel disease [2]. Curcumin, as a polyphenolic compound from the Curcuma longa plant, has a role in the context of cancer and inflammatory diseases [3].

On the contrary, the synthetic anti-inflammatory drugs, or the antiphlogistics, belong to distinct chemical groups. From the therapeutic point of view the most important ones are salicylates [4], pyrazoles and pyrazolidines [5], and quinoline derivatives [6].

***Author for Correspondence**
Khalid M. Darwish
E-mail: kdarwish1962@gmail.com

[1]Faculty of Science, Department of Chemistry, University of Benghazi, Benghazi, Libya
[2]Student, Department of Chemistry, University of Benghazi, Benghazi, Libya

Received Date: December 03, 2025
Accepted Date: December 14, 2025
Published Date: December 15, 2025

Citation: Khalid M. Darwish, Ehab El-Hawary. Organic Compounds as Anti-inflammatory Agents, Natural and Synthetic. Research & Reviews: A Journal of Drug Design & Discovery. 2026; 13(1): 5–18p.

ANTI-INFLAMMATORY HERBAL DRUGS AND THEIR SOURCES

- *Turmeric:* Contains curcumin (Figure 1), a powerful anti-inflammatory and antioxidant α,β-unsaturated carbonyl compound, and is used to treat conditions such as arthritis and irritable bowel syndrome [7]. The side effects may include nausea and vomiting, acid reflux, stomach upset, diarrhea, or constipation.

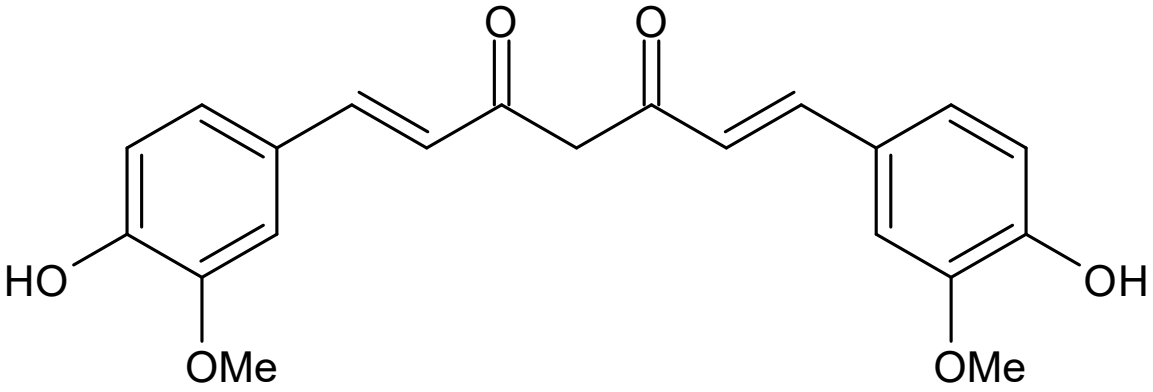
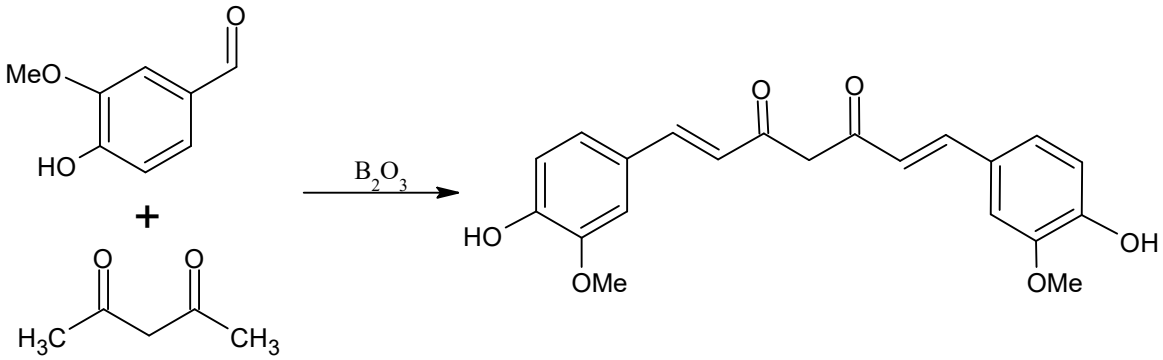


Figure 1. Molecular structure of curcumin.

Synthesis

Condensing 2 parts of vanillin and 1 part of acetylacetone in the presence of boron trioxide produce curcumin in a low yield (Scheme 1) [8].



Scheme 1. Synthesis of curcumin.

- *Ginger:* Known for its anti-inflammatory properties and its ability to relieve headaches and nausea [9]. Its chemical composition is shown in Figure 2.

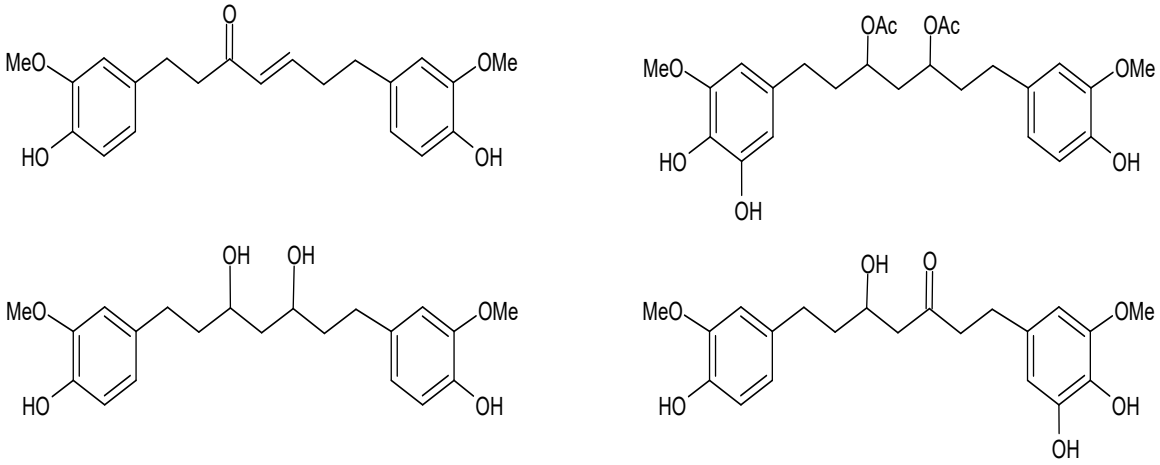


Figure 2. Molecular structure of the aromatic ginger compounds.

- *Garlic:* It contains anti-inflammatory, antibacterial, and antiviral compounds, and helps relieve the symptoms of arthritis. These compounds include allicin, diallyl sulfide, diallyl disulfide, and diallyl trisulfide (Figure 3) [10].

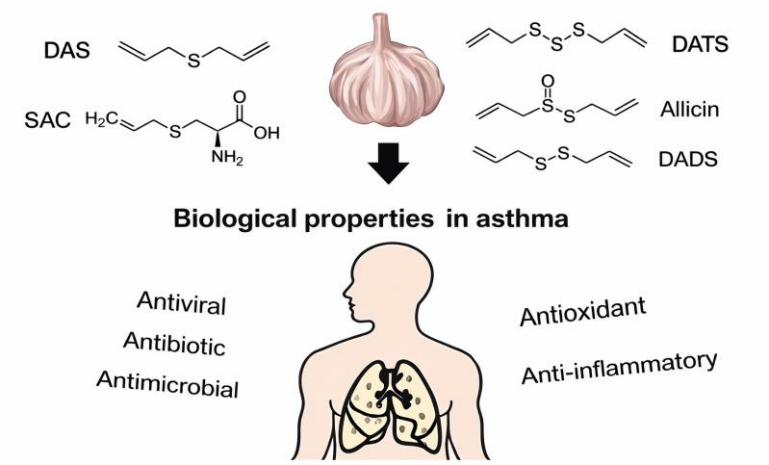


Figure 3. Sulfur compounds present in garlic.

- *Leafy Green Vegetables:* Spinach [11] and broccoli [12], are rich in antioxidants and flavonoids, which contribute to cellular health and reduce inflammation. Spinach anti-inflammatory organic compounds primarily flavonoids like quercetin, luteolin, and kaempferol, and carotenoids such as lutein and beta-carotene. Broccoli anti-inflammatory organic compounds are isothiocyanates like sulforaphane, and polyphenols such as the flavonoids quercetin and kaempferol, and various phenolic acids (Figure 4).

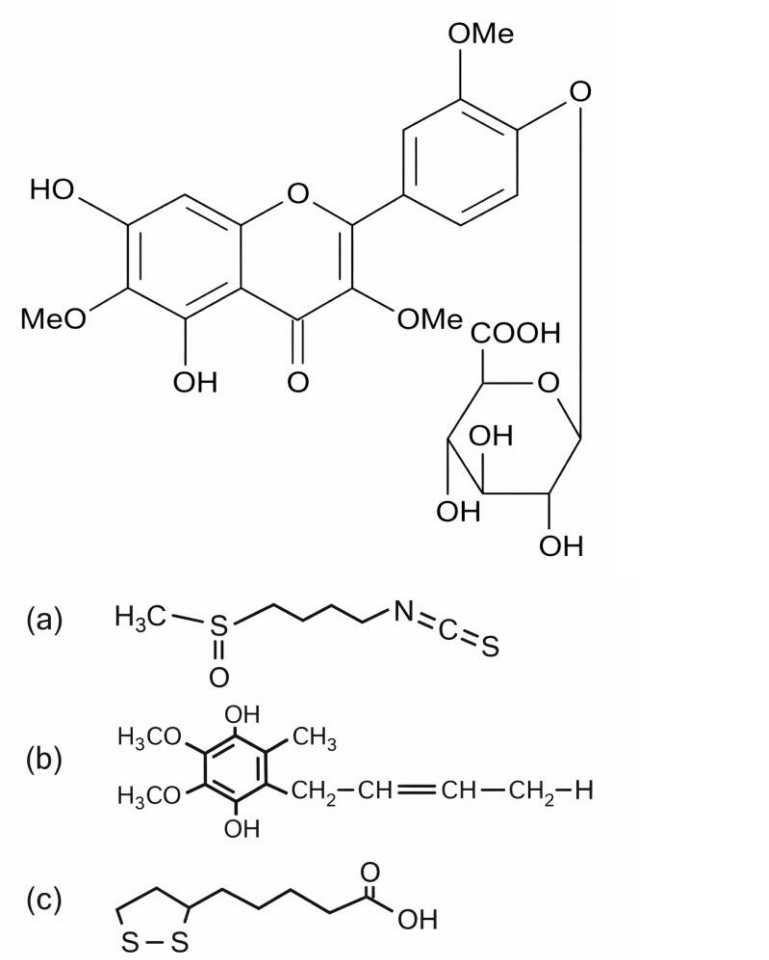


Figure 4. Anti-inflammatory organic compounds in spinach (left) and broccoli (right).

- *Ginseng:* Helps reduce inflammation, boost immunity, and support brain function. The chemical structure of its compounds is based on a dammarane skeleton with various sugar molecules attached (Figure 5) [13], classified into protopanaxadiol (PD) and protopanaxatriol (PT) types.

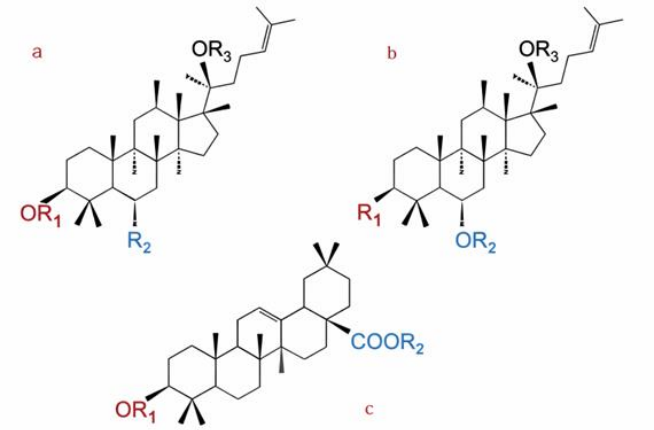


Figure 5. Chemical structures of three ginseng saponin types: (a) protopanaxadiol type (PPD); (b) protopanaxatriol type (PPT); and (c) oleanolic acid type.

- *Blueberries:* They are considered a powerful anti-inflammatory and antioxidant. They contain anthocyanins, which are a type of flavonoid, as well as other phenolic compounds like flavonols and phenolic acids (Figure 6) [14].

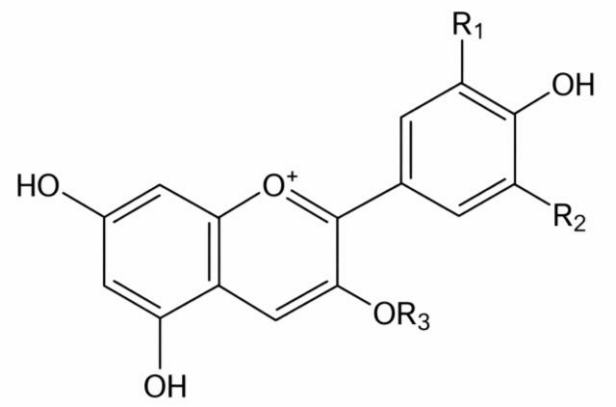


Figure 6. Anti-inflammatory organic compounds in blueberries.

- *Clove:* Traditionally used to relieve toothaches due to its anesthetic and antibacterial properties, it also has anti-inflammatory properties. Eugenol (Figure 7) [15], a phenylpropene with a benzene ring, an allyl group (CH_2–CH=CH_2), and a hydroxyl group (–OH).

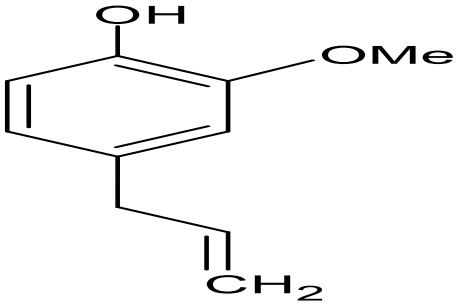


Figure 7. Structure of eugenol.

- *Aloe vera:* It contains components called saponins that have anti-inflammatory properties. polysaccharides (e.g., acetylated glucomannan), anthraquinones (e.g., aloin, aloe-emodin), vitamins (A, C, B12), enzymes (amylase, catalase), minerals (calcium, potassium), and other organic compounds like fatty acids, amino acids, and sterols (Figure 8) [16].

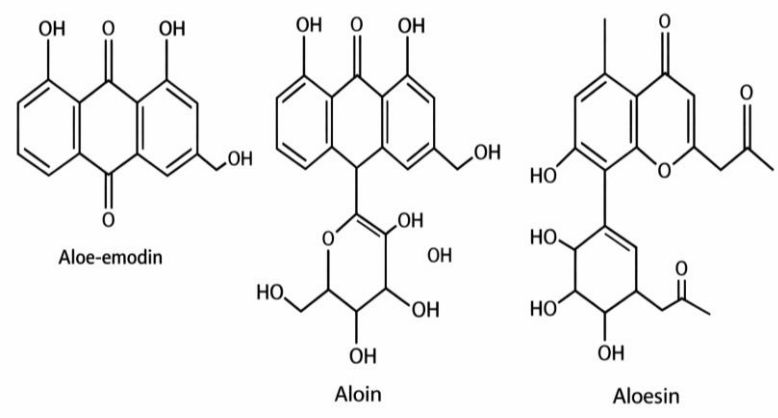


Figure 8. Compounds of aloe vera (saponins).

- *Pineapple:* Contains enzymes such as bromelain, which aid digestion and may contribute to reducing inflammation (Figure 9) [17].

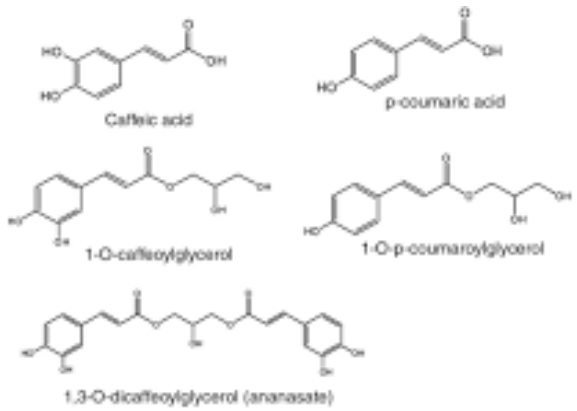


Figure 9. Compounds constituting pineapple.

SYNTHETIC ANTI-INFLAMMATORY DRUGS (ESPECIALLY IN LIBYA)

Ibuprofen

Description

An NSAID derived from carboxylic acids; it inhibits COX-1 and COX-2 (non- selectively) to reduce prostaglandins. It is used for pain relief, fever reduction, and inflammation reduction. Side effects: Gastrointestinal upset, ulcers, allergic reactions (Figure 10).

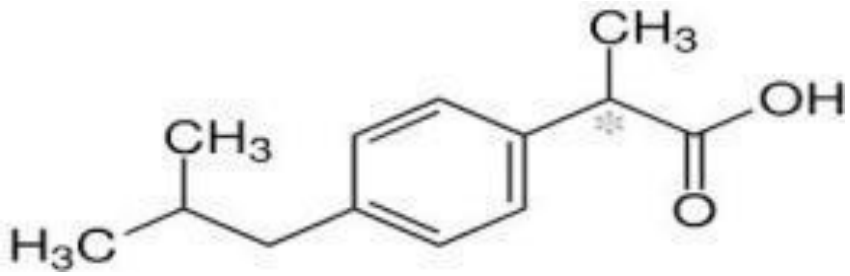
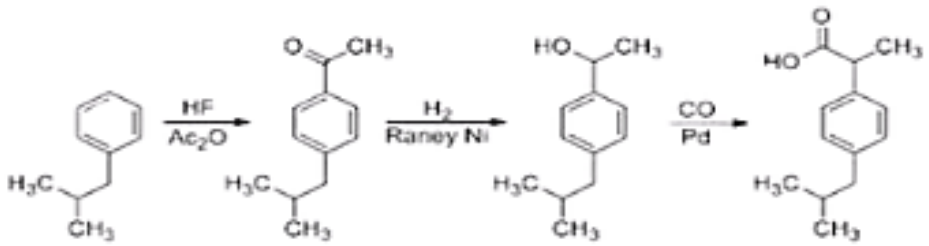


Figure 10. Structure of ibuprofen.

Synthesis (Overview)

Preparation of aromatic ketone → reduction/conversion to alcohol → Conversion to halide → Grignard reaction → Oxidation/conversion to carboxylic acid (traditional isopropyl route) (Scheme 1) [18].



Scheme 1. Corporate synthesis of ibuprofen drug.

Diclofenac

Description

A tricyclic NSAID that inhibits COX, effective for chronic pain and inflammation. Side effects: Gastrointestinal and hepatic effects, and occasionally hypertension (Figure 11).

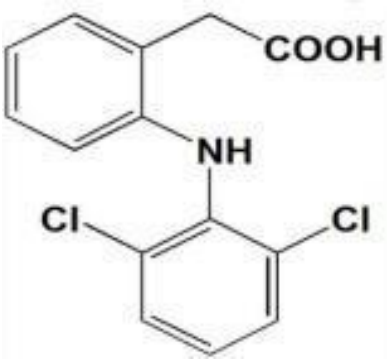
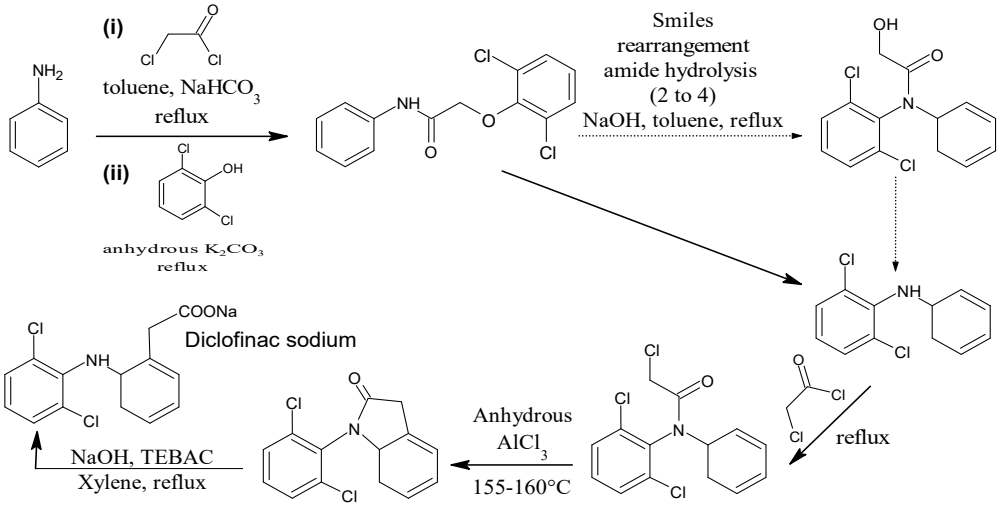


Figure 11. Structure of diclofenac.

Synthesis

Combination of aromatic amine with chloroacetyl chloride → locking of a diphenylamine ring → processing to obtain the carboxyl form (Scheme 2) [19].



Scheme 2. Synthesis of diclofenac.

Ketoprofen

Description

An acidic NSAID from the propionic acid family (Figure 12). It reduces inflammation and pain by inhibiting COX. Side effects: Gastrointestinal upset and skin sensitivity.

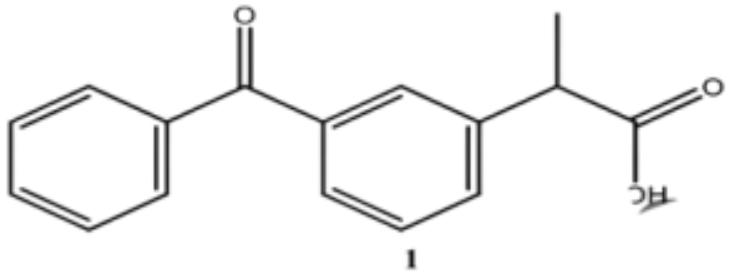
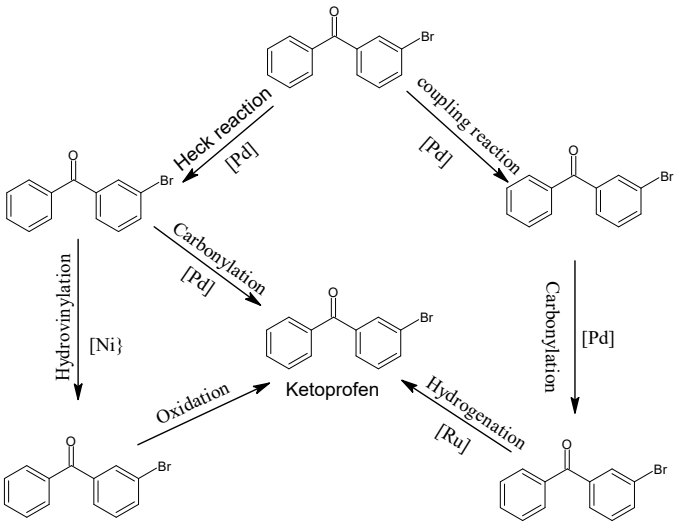


Figure 12. Structure of ketoprofen.

Synthesis

Formation of an aromatic ketone first by bromination of benzoic acid gave 3-bromobenzoic acid. Second, the acid was converted into the acid chloride with SOCl2 which by a Friedel-Crafts reaction with AlCl3 and benzene. The product is converted to ketoprofen by transition metal catalyzed reaction (Scheme 3) [20, 21].



Scheme 3. Synthesis of ketoprofen.

Aspirin (Acetylsalicylic Acid)

Description

A conventional NSAID that inhibits COX via acetylation; used as an analgesic, antipyretic, and anticoagulant at low doses. Side effects: Gastrointestinal bleeding, allergic reactions (Figure 13).

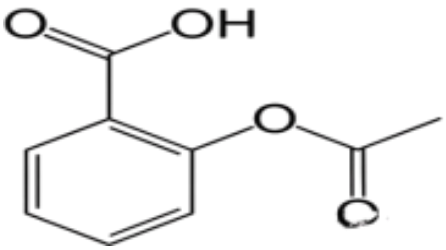
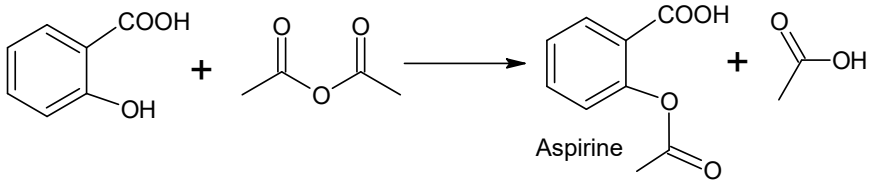


Figure 13. The structure of acetylsalicylic acid (aspirin) compound.

Synthesis

Esterification of salicylic acid by acetic anhydride or acetic acid chloride (Scheme 4) [22].



Scheme 4. Synthesis of aspirin.

Naproxen

Sold under the brand name Aleve among others, is a nonsteroidal anti-inflammatory drug (NSAID) (Figure 14), used to treat pain, menstrual cramps, and inflammatory diseases such as rheumatoid arthritis, gout, and fever.

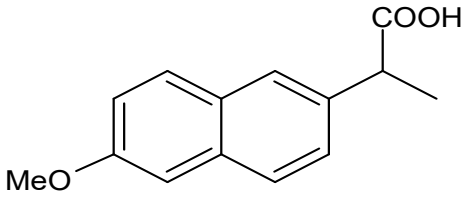


Figure 14. Structure of naproxen.

Synthesis

Commonly, starting from 2-methoxynaphthalene (nerolin) and using Friedel-Crafts acylation to form 2-acetyl-6-methoxynaphthalene, followed by steps like the Willgerodt reaction and α-methylation to obtain naproxen (Scheme 5) [23].

Scheme 5. Synthesis of naproxen.

SOME ANTI-INFLAMMATORY DRUGS RARELY USED IN LIBYA

Celecoxib

Description

A selective COX-2 inhibitor (NSAID) used in osteoarthritis and rheumatism; it reduces gastrointestinal side effects compared to non-selective NSAIDs but may increase cardiovascular risk (Figure 15).

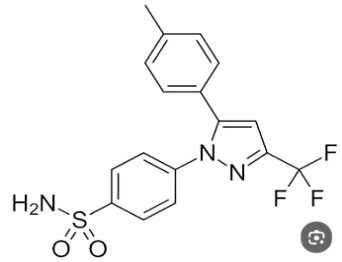


Figure 15. Celecoxib.

Mefenamic Acid

Description

From the anthranilic acid family (fenamates), used for mild to moderate pain and inflammation. Side effects: Gastrointestinal upset and allergic reactions (Figure 16).

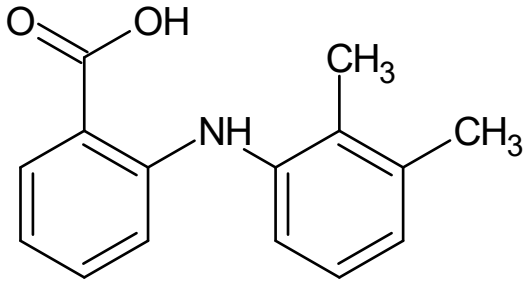


Figure 16. Mefenamic acid.

Etoricoxib

Description

A selective COX-2 inhibitor used for arthritis, gout, and inflammatory pain; potentially causes fewer cardiac and gastrointestinal side effects (Figure 17).

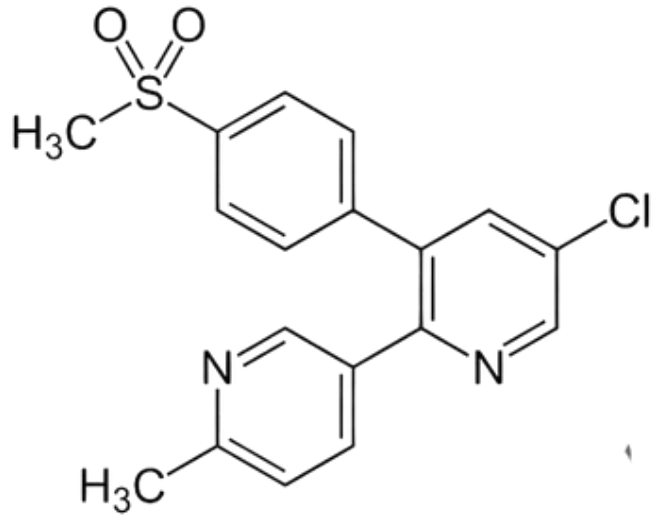


Figure 17. Structure of etoricoxib.

Flurbiprofen

Description

An NSAID from the propionic family; used for the relief of pain and inflammation. Available in topical and systemic dosages. Side effects are similar to other NSAIDs (Figure 18).

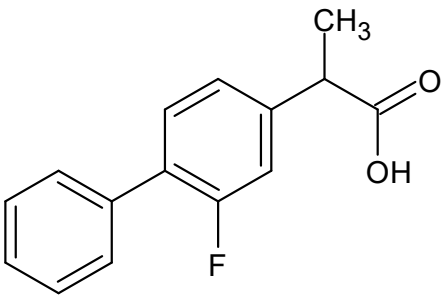


Figure 18. Structure of flurbiprofen.

Indomethacin

Description

A potent NSAID that acts on COX and affects other enzyme conversions; used in severe inflammatory conditions. Side effects: Gastric ulcers, neurological effects in some patients (Figure 19).

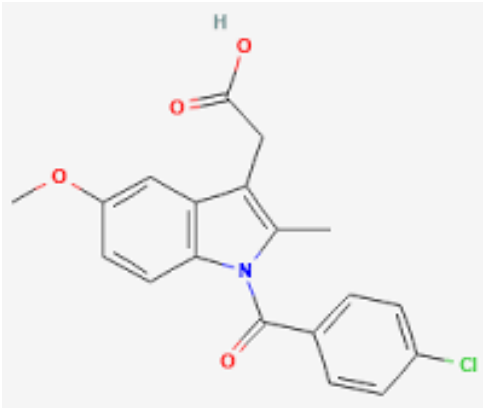


Figure 19. structure of indomethacin.

Piroxicam

Description

An NSAID of the oxicam class; it has a long duration of action and is used in rheumatic diseases. Side effects: Skin disorders and gastrointestinal bleeding (Figure 20).

Figure 20. Structure of piroxicam.

Meloxicam

Description

An oxicam-class NSAID with relative COX-2 selectivity; used for arthritis with better gastrointestinal tolerance than some others. Side effects: Possible renal and gastrointestinal effects (Figure 21).

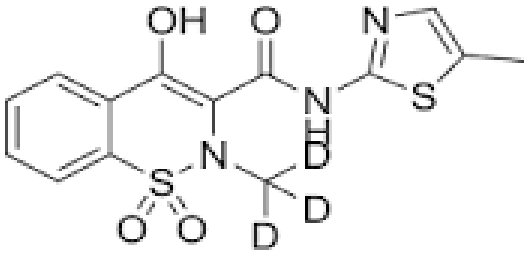


Figure 21. Structure of meloxicam.

Oxaprozin

Description

An NSAID from the propionic acid derivative class; used for chronic pain and arthritis. Side effects: Gastrointestinal irritation and sometimes skin rash (Figure 22).

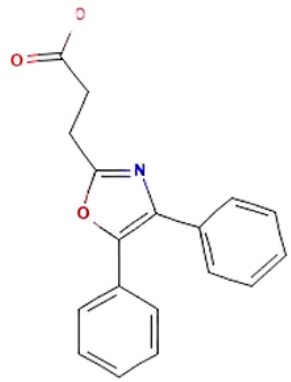


Figure 22. Structure of oxaprozin.

Sulindac

Description

A prodrug NSAID that is hepaticly metabolized to the active sulfoxide; used for arthritis and pain. Side effects: Possible liver disturbance and gastrointestinal bleeding (Figure 23).

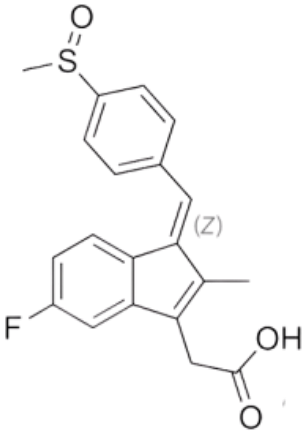


Figure 23. Structure of sulindac.

Tolmetin

Description

An NSAID from the tolmetin family, used for minor pain and inflammation. Side effects: Gastrointestinal cramps and allergic reactions (Figure 24).

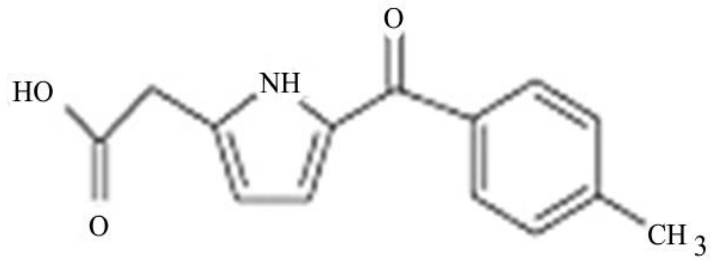


Figure 24. Structure of tolmetin.

Benoxaprofen

Description

An oxaproxenic NSAID, previously used but withdrawn due to hepatotoxicity; its academic performance is important here as a historical model. Side effects: Severe hepatotoxicity (Figure 25).

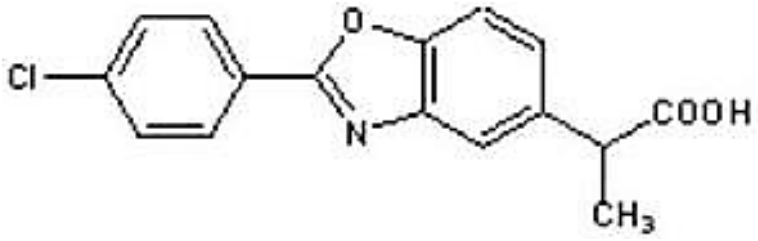


Figure 25. Structure of benoxaprofen.

Sulfasalazine (A Compound with A Mechanism of Action Suitable for Inflammatory Bowel Disease)

Description

A dual compound that acts locally in the intestine (prodrug) and is hydrolyzed to 5-ASA and sulfapyridine; used in the treatment of inflammatory bowel disease and arthritis. Side effects: Skin sensitivity, oligocytosis (Figure 26).

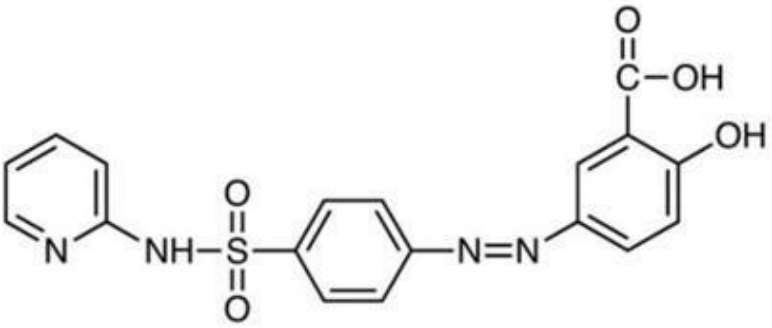


Figure 26. Structure of sulfasalazine.

Salsalate

Description

Disalicylic acid is known for its anti-inflammatory effect with less gastric irritation compared to some NSAIDs. Side effects: Mild digestive disturbances (Figure 27).

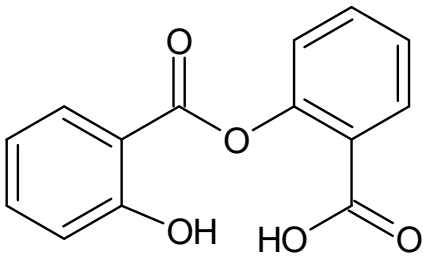


Figure 27. Structure of salsalate.

Lumiracoxib

Description

A selective COX-2 inhibitor with an atypical acidic structure; it was introduced as a selective option, but hepatotoxicity has been observed in some patients. Side effects: Possible hepatotoxicity and gastrointestinal side effects (Figure 28).

Figure 28. Structure of lumiracoxib.

Sulfone-Derived Experimental Cox Inhibitors (General Example – Scaffold Study)

Description

A research class of aromatic compounds with a sulfonylurea group exhibiting heterogeneous selectivity for COX-2. They are used as research models for developing less toxic NSAIDs. Side effects: Peripherally dependent but may include allergic and nephrotoxic effects (Figure 29).

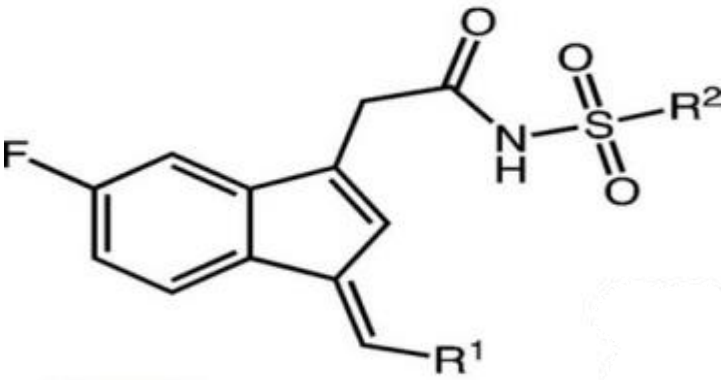


Figure 29. Experimental sulfone-derived COX inhibitors.

PROPOSED PRECAUTIONS

- It is important to know the origin of drug manufacturers of imported medicines and their expiry date, since many companies entered this field, only for getting money.
- The origin of inflammation comes from individuals' ignorance for injuries, toothache, and inflammation, and postponing routine life check-up.
- First-Aid kits should be available everywhere, including schools, institutes, universities, workshops, companies, etc.

CONCLUSION

1. Anti-inflammatory organic compounds, either of natural or synthetic origin have the same importance.
2. Although natural drugs are expensive, synthetic anti-inflammatory drugs have comparatively higher prices.
3. The use of artificial intelligence is important and may reduce the cost in future.
4. Continuous research studies regarding anti-inflammatory drugs should be enhanced by governments.

REFERENCES

1. Upadhyay RK. Anti–inflammatory activity of plant-derived natural bio-organic ingredients: A review. Int J Green Pharm. 2025;19(2):65.
2. Saadati F, Chahardehi AM, Jamshidi N, Jamshidi N, Ghasemi D. Coumarin: A natural solution for alleviating inflammatory disorders. Curr Res Pharmacol Drug Discov. 2024;7:100202.

3. Moon DO. Curcumin in cancer and inflammation: An in-depth exploration of molecular interactions, therapeutic potentials, and the role in disease management. Int J Mol Sci. 2024;25:2911.
4. Zheng L, Howell SJ, Hatala DA, Huang K, Kern TS. Salicylate-based anti–inflammatory drugs inhibit the early lesion of diabetic retinopathy. Diabetes. 2007;56:337–45.
5. Alsimaree AA. Recent advances on antiproliferative and anti–inflammatory potential of pyrazoline derivatives. Biointerface Res Appl Chem. 2025;15(2):16.
6. Mali V, Patil G, Shaikh S. Int J Innov Res Technol. 2025;12(7):2349–6002.
7. Jurenka J. Anti-inflammatory properties of curcumin, a major constituent of Curcuma longa: A preclinical and clinical research. Altern Med Rev. 2009;14(2):141–53.
8. Pabon HJJ. Synthesis of curcumin and related compounds. Recl Trav Chim Pays–Bas. 1964;83:379–86.
9. Kravchenko I, Eberle L, Nesterkina M, Kobernik A. Anti-inflammatory and analgesic activity of ointment based on dense ginger extract (Zingiber officinale). J Herbmed Pharmacol. 2019;8(2):126–32.
10. Khan AM, Sharif MA, Salekeen R, Rahman MH, Mahmud S, Biswas P, et al. In vitro and in silico investigation of garlic's (Allium sativum) bioactivity against 15-lipoxygenase mediated inflammopathies. J Herbmed Pharmacol. 2023;12(2):283–98.
11. Morishita Y, Saito E, Takemura E, Fujikawa R, Yamamoto R, Kuroyanagi M, et al. Flavonoid glucuronides isolated from spinach inhibit IgE-mediated degranulation in basophilic leukemia RBL-2H3 cells and passive cutaneous anaphylaxis reaction in mice. OAT. 2015. DOI:10.15761/IMM.1000119.
12. Hashem AMA, Abuzeid H, Winter M, Julien CM. Synthesis of high surface area α-$KyMnO_2$ nanoneedles using extract of broccoli as bioactive reducing agent and application in lithium battery. Materials. 2020;13(6):1269.
13. Shi ZY, Zeng JZ, Wong AST. Chemical structures and pharmacological profiles of ginseng saponins. Molecules. 2019;24(13):2443.
14. Patel S. Blueberry as functional food and dietary supplement: The natural way to ensure holistic health. Mediterr J Nutr Metab. 2014;7:133–43.
15. Ulanowska M. Biological properties and prospects for the application of eugenol—A review. Int J Mol Sci. 2021;22(7):3671.
16. Khaldoune K, Fdil N, Ait Ali M. Exploring Aloe vera: A comprehensive review on extraction, chemical composition, biological effects, and its utilization in the synthesis of metallic nanoparticles. Biocatal Agric Biotechnol. 2024;27:103052.
17. Hu J, Lin H, Shen J, Lan J, Ma C, Zhao Y, et al. Developmental toxicity of orally administered pineapple leaf extract in rats. Food Chem Toxicol. 2011;49:1455–63.
18. Abualhasan M, Assali M, Jaradat N, Tarayra R, Hamdan A, Ardah R, et al. Synthesis and formulation of ibuprofen pro-drugs for enhanced transdermal absorption. Int J Pharm Pharm Sci. 2015;7(2):352–4.
19. Labidi A. Diclofenac synthesis. Org Chem Organomet Chem. 2021;1:1–3.
20. Sonawane HR, Bellur NS, Kulkarni DG, Ayyangar NR. Tetrahedron. 1994;50:1243.
21. Ramminger C, Zim D, Lando VR, Fassina V, Monteiro AL. Transition-metal catalyzed synthesis of ketoprofen. J Braz Chem Soc. 2000;11(2):105–11.
22. Klein D. Organic chemistry. 2nd ed. USA: John Wiley & Sons, Inc.; 2015.
23. Mena SS, Gallardo I, Guirado G. Sustainable and efficient electrosynthesis of naproxen using carbon dioxide and ionic liquids. Chemosphere. 2020;245:1.

