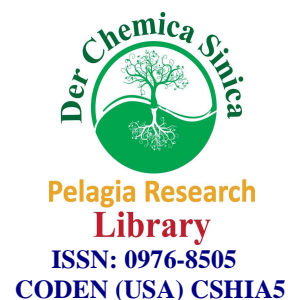




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### Science of imide with study case in Iraq: A mini review

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#### ABSTRACT

Many conventional syntheses and other techniques that produce unsubstituted or substituted imides with their wide application in life and science have been mainly reviewed with special focusing on Iraqi universities and scientific research centers works until now.

**Keywords:** imide, application, synthesis, Iraq

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#### INTRODUCTION

The applications of organic molecules or polymers that contain imide as a functional group in their structure reflect the importance to search for new modified methods of synthesis. In this short review, I will present these applications as possible with one example (or more) that published recently and done by MSc and PhD students and researchers in Iraq.

#### **Definition, synthesis methods, and applications for organic molecules containing imide:**

Imides are acyclic or 4, 5, or 6 cyclic organic compounds of N-monoacyl derivatives [1]. General and special methods of synthesis, chemical and physical properties, detection, and uses of cyclic carboxylic monoimides until 1969 have been reviewed by M.K. Hargreaves et al. [2].

Dehydration of amic acids gives two isomers, imides and isoimide, depending on the nature of dehydrating agent, temperature, time of reaction, nature of amic acid, and the presence or absence of the catalyst [3]. Many dehydrating agent has been used for imide synthesis for examples, thionyl chloride [4,5], acetyl chloride with triethyl amine [6,7], acetic anhydride with anhydrous sodium acetate [5,8,9], phosphorous trichloride [5,10], and phosphorous pentaoxide [5,11]. Beside amic acids, isocyanate with anhydride [12] or ketene [13] can be used in preparation cyclic imide. Thermal process can be used instead of using dehydrating agent to prepare imide from the corresponding amic acid [14].

#### **Diels Alder reaction:**

Diels – Alder reaction applied through many dienes molecular complexes ( $\pi$ - $\pi$ ) type due to the interaction of the highest occupied  $\pi$ -orbital of a diene donor with the lowest unoccupied  $\pi$ -orbital of a dienophile-acceptor in presence or absence of catalyst [15].

**Microwave method application:**

The known typical method of imide preparation by cyclization of amic acid with acidic reagents may be done in one step by dehydration of an anhydride and an amine mixture at high temperature. Most maleimides preparation methods depending on N. E. Searle [8] noticed by V. Ondrus et al. [16] and encouraged them to apply thermal method or microwave irradiation with the presence of water in both cases. Since polar reactants can adsorb microwave irradiation, chemists can utilize the microwave oven for some organic reactions. The application of microwave technology in many conventional syntheses offers many advantages including increased product yields and decreased reaction times [17].

The synthesis of unsubstituted cyclic imides either by conventional methods or microwave irradiation is often carried out by the reaction of cyclic anhydrides with reactants including ammonia, formamide, lithium nitride urea or thiourea, benzonitrile, cyanate, thiocyanate, 4-N,N-dimethylamino-pyridine /ammonium chloride, ammonium acetate, hydroxyl amine hydrochloride, and 4-N,N-dimethylamino-pyridine [18].

Lactams, which need not be N-substituted, can be converted to cyclic imides by oxidation with a hydroperoxide or peracid and a transition metal salt [19, 20] under microwave irradiation in good yields. The Michael reaction of synthesis of N-alkyl derivatives of phthalimide and saccharin was achieved with solvent-free thermal or microwave conditions as green chemistry protocols [21].

Bisimides as heterocyclic precursors in organic supramolecular and polymer chemistry can be formed with all known imidic formation routes with their limitations such as time, yield, using non- green or toxic solvents, purification after workup procedures beside formation of byproducts [22].

**Miscellaneous synthesis methods and applications:**

Synthetic cyclic imides possess structural hydrophobic feature with potential biological and pharmaceutical actions [23], pesticides, retarders of electrochemical decomposition of electrolyte in accumulators, dispersants of passenger car motor oils, and accelerators in organic chemistry [24], ashes- free additives without phosphorus and sulphur [25], fluorescence properties as convenient solvatochromic fluorescent dye, chemosensor [26].

**Synthesis methods and applications for polymers containing imide:**

Polyimides [27] can be made by either thermal imidization or by chemical imidization, starting from poly(amic acids). Chemical imidization used a dehydrating agent has many advantages over thermal imidization accompanied with experimental factors such as the type of solvent, temperature, the concentration of amic acid, and the composition of the imidizing mixture (dehydrating agent and catalyst).

Many articles describe [28] in details that aromatic polyimides have unique excellent thermal, mechanical, and electrical properties, chemical resistance, used in the aerospace, transportation, and electrical and microelectronic industries, and are insoluble in common organic solvents and intractable in their imide forms. Most of them have strong absorption in the visible region due to the existence of charge transfer complexes especially in the fields of optical transparency, high birefringence, and enhanced solubility.

Electrochromic conjugated polymers received attention of researchers for automatic anti-glazing mirror, smart windows, electrochromic displays, and chameleon materials [29] especially with imide presence [30] for holography [31], optically induced anisotropy [32].

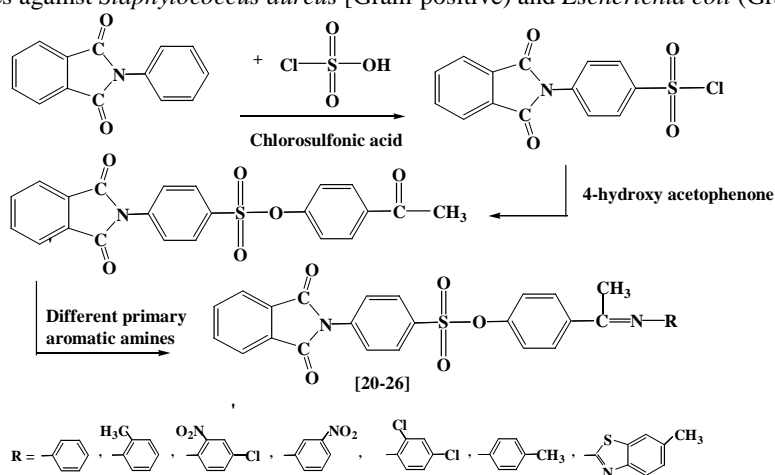
Other excellent property of newly synthesized imide containing polymer is its thermal property combined with high char yield [33] utilized in electronic devices such as dielectric interlayer and flexible circuit boards due to their excellent thermal, mechanical and electrical properties, good chemical resistance, and high dimensional stability [34], applied as membranes for gas separation, electronic applications, high temperature insulators for aircraft wire coatings, and advanced composite materials [35].

Polymeric drugs with anticancer drugs such phthalimide polymers were obtained by covalent linking of anticancer drugs to polymers with directly imide functional groups or by other chemical spacer linkage [36].

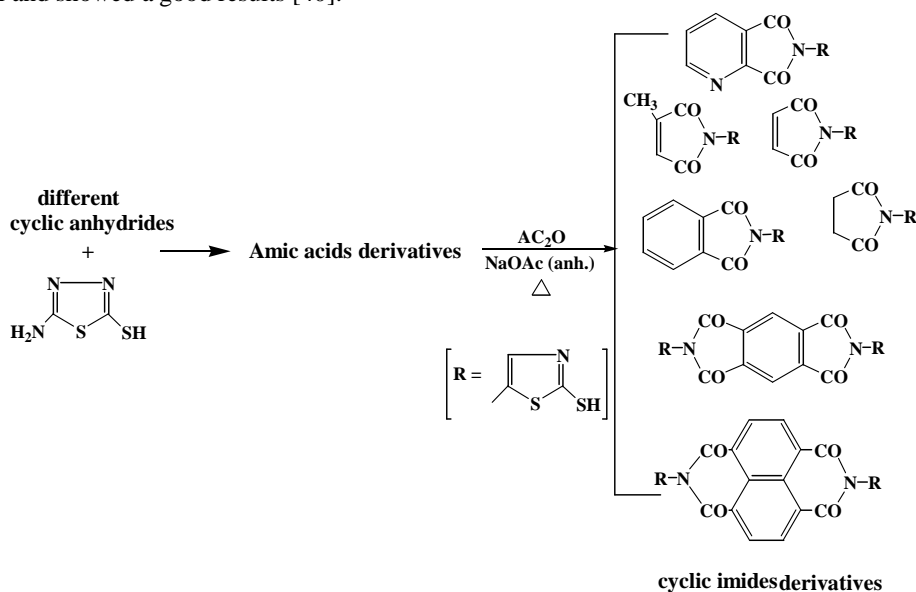
**Imide in Iraq:**

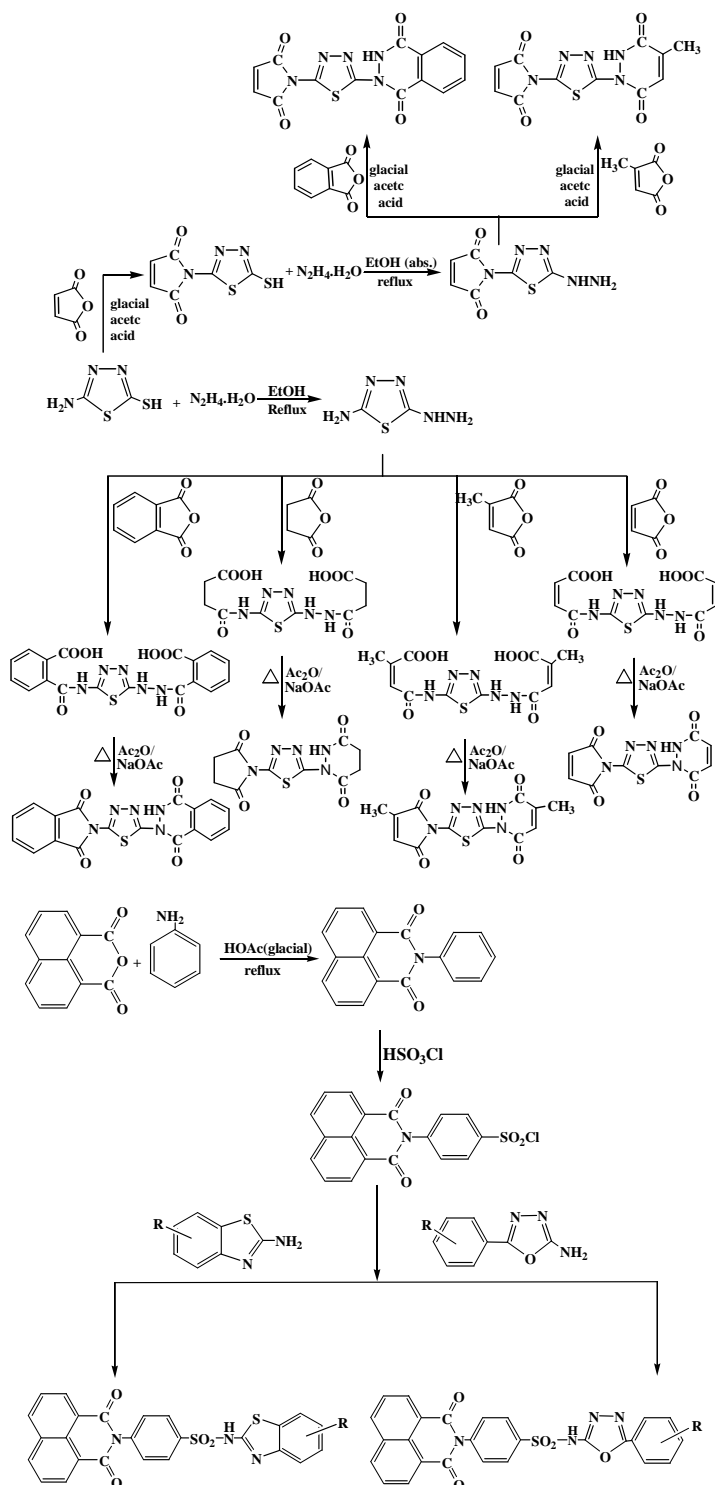
The start of imide science in Iraq began with Prof. Dr T. Pyriadi, his students and colleagues' works [3, 38]. Several published articles and theses put their main concerns with synthesis and characterization of new imide derivatives or polymers containing imide moiety. The main notices in these works are the large number of the prepared organic derivatives with / without their corresponding polymers or copolymers, application of different organic synthetic pathways, and with shortage in their applications. Some of them were preliminary tested as antimicrobial agents. Below some of these scientific contributions in imide chemistry here in Iraq as theses or scientific research articles where many of them were part of MSc and PhD theses.

Abd Al-Razzak MSc thesis [39], 2012 discussed the synthesis and characterization of new phthalimides linked to Schiff base through different strategies with four main parts. Several of the prepared derivatives showed good antibacterial activities against *Staphylococcus aureus* [Gram-positive] and *Escherichia coli* (Gram-negative)

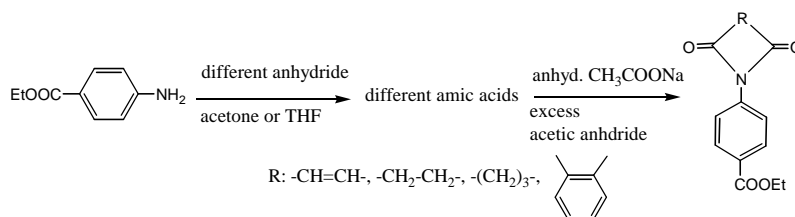


Hamd PhD project, 2012 involved synthesis and characterization with UV-Vis., FTIR, <sup>1</sup>HNMR, and <sup>13</sup>CNMR spectroscopies of N-substituted cyclicimides containing hetero rings. Some of the (115) prepared organic derivatives have been screened for their biological activities against Gram positive bacteria (*Staphylococcus aureus* and *Streptococcus pyogenes*), Gram negative bacteria (*Escherichia coli* and *Pseudomonas aeruginosa*), and *Candida albicans* fungi and showed a good results [40].

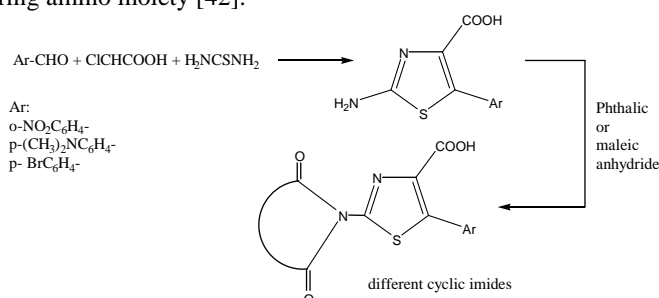




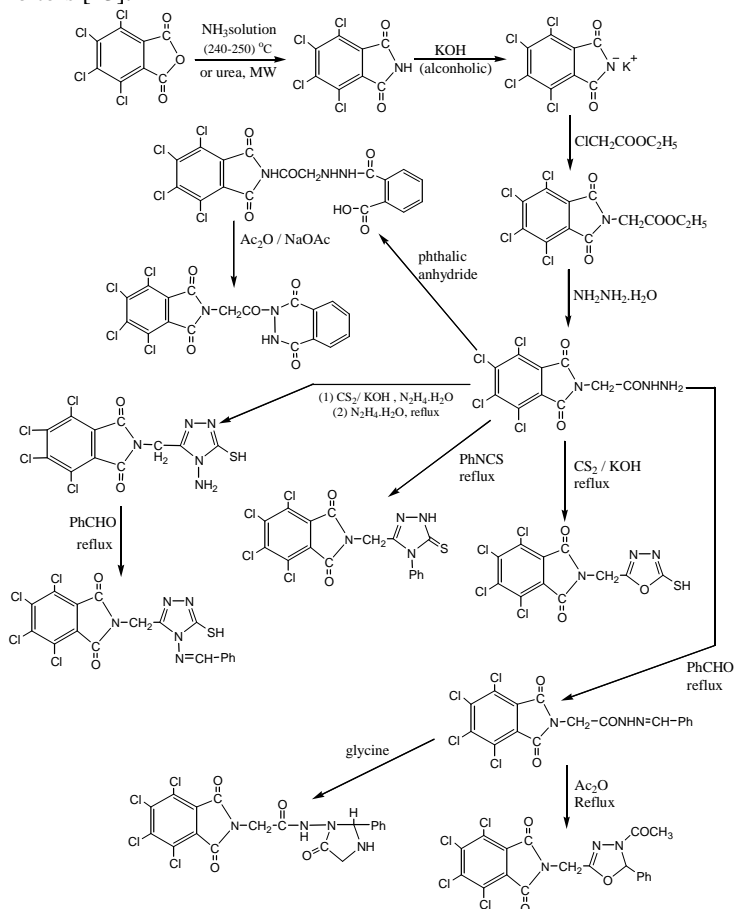
Al-Majidi and Saeed synthesized some new 1,2,3-triazole, amic acids, imides, and isoimides from ethyl-*p*-aminobenzoate and studied their biological activity against (*Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Escherichia coli*) [41].

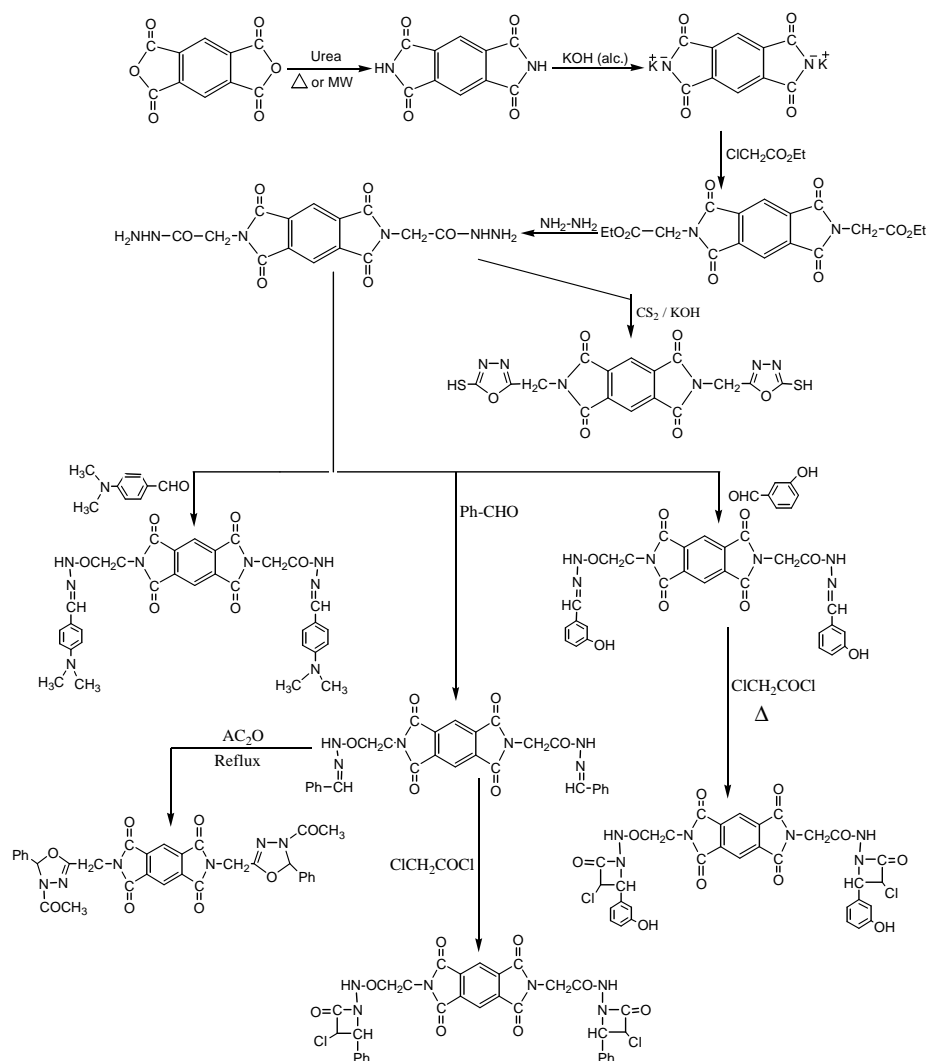


Some of Iraqi researchers did not directed their main target to the synthesis of imide derivatives but it was as an additional derivative prepared with the presence of amino group in their first setup synthesized compounds. With this direction, Al-Dulaimy et al., 2013 prepared phthalimide and maleimide in the presence of glacial acetic acid and different 1,3-thiazoles bearing amino moiety [42].



Al Obaidi, 2013 presented in her PhD thesis five parts of synthesis of new heterocyclic derivatives containing in many of (75) prepared derivatives by conventional and non-conventional methods (microwave irradiation) imide moiety then followed with sixth part of studying the possibility for their application as surfactants, antimicrobial agents, or corrosion inhibitors [43].





### CONCLUSION

Many conventional syntheses and other techniques that produce unsubstituted or substituted imides with their wide application in life and science depended on several factors which include nature of dehydrating agent, temperature, time of reaction, nature of amic acid, and the presence or absence of the catalyst. All of the various classes of cyclic imides have received attention due to their antibacterial, antifungal, analgesic, and antitumor activities beside their very interesting electrochemistry and peculiar electrical transport properties.

Pesticides, retarders of electrochemical decomposition of electrolyte in accumulators, dispersants of passenger car motor oils, and accelerators in organic chemistry with imide function are also studied. Modern polymeric materials having imide in the structure of the repeating unit have been involved in modern technologies for example as materials for holography, dielectric interlayer and flexible circuit boards, membranes for gas separation, electronic applications, high temperature insulators for aircraft wire coatings, and advanced composite materials and others were reported.

The Iraqi chemist contributions in imide science were subjected in main goal that is synthesis of new derivatives and characterization them with modern spectroscopic and thermal techniques. The large number of these prepared compounds might be combined with polymer section where imide was the specific purpose of the overall work giving a good chance to polymerization process to be achieved or as a pended group in modified polymers. Also,

Iraqi chemists put their focusing in antibacterial and antifungal activities after preparation and characterization steps with lack of other important applications.

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