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A Review on Recent Publications Using Microwaves in Synthesis of Biologically Active Molecules

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Mini-Review

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ABSTRACT

There various methods adopted in synthetic organic chemistry including microwave assisted synthesis, sonochemistry and green chemistry. Applications of all microwaves in the synthesis of chemical moieties which are biologically active have been discussed with a short briefing of advantages of these techniques over the conventional approaches.

INTRODUCTION

The chemical moieties synthesized in organic chemistry are mostly the starting materials for the industrial production of pharmaceuticals [1-8], pesticides, polymers, food additives, colorants, etc. The conventional method of organic synthesis [9] involves of large amounts of solvents, high energy consumption, high quantities of catalysts, and also involves hectic procedures for purification of the products. The conventional methods also are responsible for many health issues to the handling people and also environment. The major harm to the people and environment is by the use of volatile [10-41] organic compounds (VOCs). VOCs are responsible for respiratory problems, allergic reactions, and also know to have immunogenic effects on children. The main of VOCs is in synthetic chemistry and manufacture of paints. VOCs not only harm the mankind but also the environment in many ways, the popular one being ozone [42-59] layer depletion.

To overcome all these, the researchers are always working on discovering alternatives which led to the development of novel approaches in organic synthesis like microwave assisted synthesis, sonochemistry, green chemistry [60-65] and other procedures. Though all these techniques doesn't assure of being advantageous over the conventional methods, they are safer to prefer.

Microwave assisted organic synthesis

In early days when it was discovered that microwaves heat water quickly, the scientists have incorporated this technique in home appliances to cook and heat the food products. Microwaves are electromagnetic waves which are located between the infrared and radio waves (wavelength: 1mm to 1 m; frequency: 30 Hz to 3 GHz). This range of radiations was used in telecommunication equipments and

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later the industrial use of frequency was declared as 2.45 GHz by an international convention [66-117]. Microwaves are not only used in chemistry but also in all the fields of research [118,119].

During the past fifteen years, the use of microwaves in chemical synthesis have been extensively increased which can be inferred from the vast number of publications related to organic synthesis using microwaves. The number of publications involving organic synthesis is >2000 and the first one was by Gedye et al. [120] and Giguere et al. [121]. These revolutionary publications were followed by several publications with microwave assisted organic synthesis including both solvent and solvent free synthesis [122-125].

Brief principle and theory of microwaves

Microwaves are an electromagnetic radiation which acts as non-ionizing radiations causing molecular motions and rotation of the dipoles without affecting the basic molecular structure. Heat is produced as a result of rotating dipoles. Once the field is removed, the molecules return to a relaxed state releasing the thermal energy. Microwave-assisted digestion, dissolution or extraction constitutes a thriving field gathering the thermal effects of microwaves and their chemical effects (dielectric polarization). Thus, the production of heat is due to the dielectric loss but not conduction or convection [126].

The heating is dependent on the dielectric properties, the loss factor (ε”) and dielectric constant (ε’). The ability of a substance to absorb microwaves is dependent on dielectric constant while the dielectric loss factor represents the ability to transform the microwave energy into heat. The microwave phenomenon is dependent on the polarity [127-133], greater the polarity greater is the phenomenon and rise in temperature. The polarity of the molecules is increased from the ground state to that of the transition state.

Most of the reactions which do not occur by classical heating and which give low yields can be performed using microwave assistance with good yields. Few authors proposed the existence of a special effect called the microwave effect for the cause instead of rapid heating. Sometimes, the microwaves may result in chemo- or region-selective reactions by serendipity.

Types of microwave oven:

1. Domestic: These are used for domestic purpose, mainly to cook food.
2. Modified: These ovens are modified according to the apparatus to be used. Eg: A condenser may be attached to support the reactions involving solvent condensation.
3. Advanced: These ovens are modified according to the chemicals to be used (anti-corrrosive).

Recent literature in synthetic organic chemistry involving microwaves

Thioethers [133] are used as starting material for synthesis of sulfones [134] and sulfoxides (important commercially) [135].

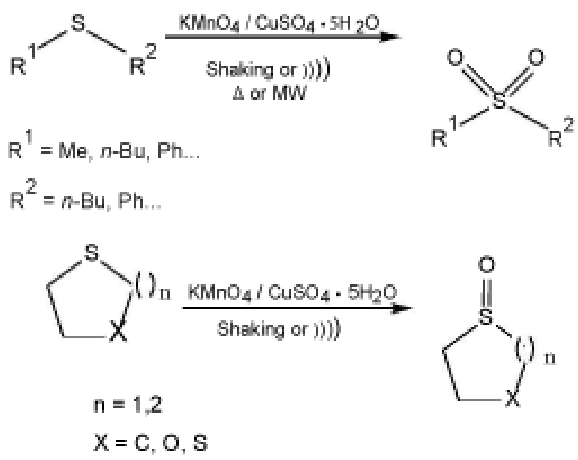

Figure 1: Green permanganate oxidation of thioethers [135].

Aromatic nucleophilic substitutions are carried out using sodium phenoxide and 1,3,5-richlorotriazine under microwave irradiation [136].

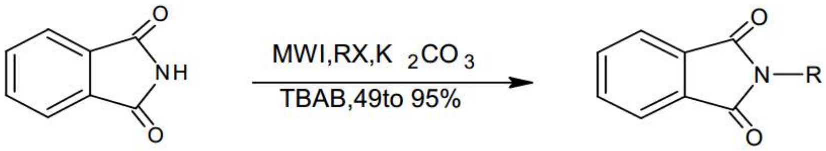

Figure 2: Synthesis of N-alkyl phthalimides using phthalimide, alkyl halides, potassium carbonate and TBA.

Synthesis of alkyl-substituted pyrroles [137-140]

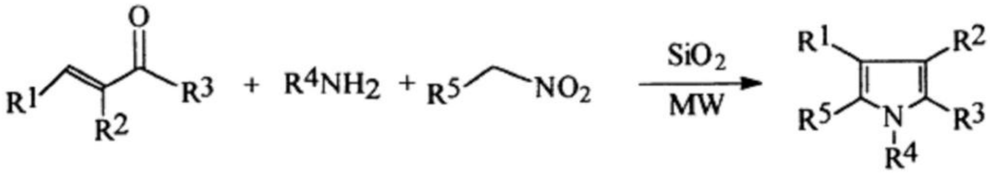

Figure 4: Synthesis of pyrrole [137].

Synthesis of arylimidazoles [141-145] in dry media in domestic oven [146].

Figure 5: Synthesis of arylimidazoles [146].

Accelerated Pechmann reaction for synthesis of coumarin derivatives [147].

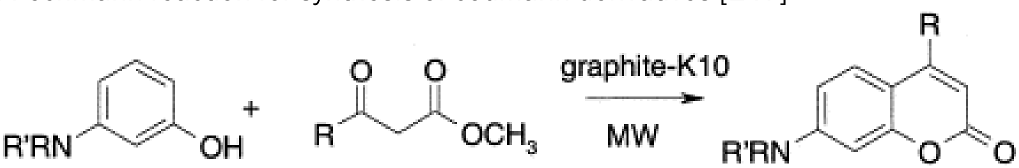

Figure 6: Synthesis of coumarin derivatives by Pechmann reaction [147].

CONCLUSION

Microwave synthesis is a very convenient way giving positive results in reactions which are either not possible or doesn’t occur by conventional methods. Thus, the short review provides a overall knowledge about the use of microwaves in organic chemistry.

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