

MICROWAVE-INDUCED ORGANIC REACTIONS: MY JOURNEY FOR THE PAST TWENTY FIVE YEARS

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Abstract:

In this perspective, our research on domestic and automated microwave-induced reactions is described in brief.

Introduction:

Since the discovery of microwave-induced organic reactions in 1986, this topic has gained significant attention from numerous chemists, biologists, and engineers.¹ A microwave oven produces non-ionizing radiation at a frequency near 2.45 GHz through chemical reactants, causing dielectric heating by absorption of the energy². It is believed that solvents and reactants undergo numerous molecular interactions at high power of microwave irradiation. The molecules and the solvent must be polar in nature in order to capture microwave radiation. Non-polar reactants in the presence of polar solvents can participate in reactions successfully. We have been conducting microwave-induced organic reaction since 1990 and our studies in this area have culminated in several papers of high interests. Microwave chemistry is the science of applying microwave radiation to chemical reactions.

Results:

We used domestic and automated microwave oven for our research. Diverse compounds were synthesized using this method. Some representatives are given below.³

Reaction of acid chloride (equivalent) with imine in the presence of a tertiary based produced beta-lactams under microwave irradiation. The ratios of the beta lactams varied from cis and trans in different proportions. This fascinating reaction depended on many components when stereochemistry of the products is concerned. The three parts present in imine and acid chloride had a profound influence. The way the reagents were irradiated had effects on product distribution. An order of addition of the reagents and power level of the microwave used had significant effects. In some instances, reactions were highly diastereoselective and enantioselective. The cause of this selectivity was also explained. Interestingly, the yields of the products and stereochemical distribution obtained from microwave-induced reactions and classical methods were different in many instances. This different could be attributed to rapid

exposure of microwave radiation to the reaction mixture and as a result, more stable product may be formed in major proportion or exclusively.

Hydrogenolysis of the benzyloxy group to the hydroxy group was performed with ammonium formate and Pd/C. No hydrogen gas was necessary. The N-C4 bond cleavage was done and open chain amides were prepared by this reagent combination. The reaction did not proceed in the absence of an aromatic ring. However, the use of more than one aromatic ring at the C-4 position of the beta-lactam ring failed to cleave the ring. Fused beta-lactams that have a single aromatic ring also failed to cleave the ring suggesting the importance of steric hindrance.

Several polycyclic beta lactam rings were prepared using suitable functionality at C-3, C-4 and N-1 in microwave following carbocation, carbanion and radical chemistry. This ring closure strategy in microwave became a convergent method of synthesizing beta lactams.

Heterocycles (imidazoles, quinazolines, dihydropyrimidine, pyrazine, indole, thiopene, pyrrole, isoquinoline, quinoline, acridine, glycoside and dihydropyridine) were prepared following microwave-induced reactions in an automated microwave oven within a few minutes. Heating involves the use of a mantle or oil bath, which usually heats the walls of the vessels by convection or conduction. The reactants take much longer time to achieve the required temperature and consequently reaction becomes much slower in the conventional heating method. In contrast, microwave irradiation is able to raise the temperature required for the reactants to participate in reactions without heating the reaction vessels. Some authors argued that in microwave superheating of the reactants is very common.⁴

Our research and other authors had demonstrated that microwave irradiation has numerous benefits over conventional heating devices in terms of acceleration of the reaction rate, mild method, useful selectivity and environmentally benign processes. Although the debate in the acceleration of reaction rate in microwave-induced method is not over, non-thermal microwave effects are believed to be involved.⁵

Conclusion:

Our research on microwave-chemistry for the past 25 years has received significant attention. Synthesis of numerous organic compounds in high yield has been possible using domestic and automated microwave ovens.

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