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Research Article

Fit-in ice condenser: Microwave Assisted Organic Synthesis-Domestic Approach

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Abstract

The main reason that organic research is lacking in developing countries like Sudan is the time-consuming nature of this type of research. Microwave induced organic synthesis overcomes that obstacle. Due to the a lack of special microwave reactors, special fit-in ice condenser for use with domestic microwave oven (DMO) was developed in this study. The esterification reaction (Diclofenac, Indomethacin, Ibuprofen methyl esters, and acetylsalicylic acid) was selected for assessment of the utility of the device. Time was reduced from the hours scale into minutes, accompanied by a reasonable increase in % yield. DMO synthesis of Diclofenac, Indomethacin, Ibuprofen methyl esters and acetylsalicylic acid was carried in 4, 8, 7.5 , and 2 min respectively. Compared with 6 h to overnight wait by the conventional method.

Keywords Microwave Assisted organic Synthesis, Domestic Microwave Organic Synthesis, Fit-in Ice Cooling Condenser, Microwave Catalysis, Esterification, Diclofenac, Indomethacin, Ibuprofen, Aspirin.

Introduction

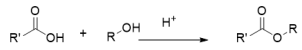
Organic synthesis is a time-consuming process, since the early beginnings of organic chemistry, scientists have tried to reduce the times needed and increase % yield.

Catalysis is the method to overcome the problems in many synthetic methods. Thermal catalysis tends to be the standard protocol, especially in old literature, but still sometimes long reaction times are required to obtain good yields. In the 80s, microwave radiation was explored in many fields, including organic synthesis. Two issues emerged: the lack of temperature control and predictability and a confined microwave oven cavity that was not suitable for condenser installation. The later issue could be solved by puncturing the oven top, which decreased the safety profile as it could lead to severe skin burns [1-3].

When more powerful and homogenous magnetrons were manufactured, special devices were developed to allow control over temperature. In Sudan, and probably many other developing countries, those special microwave reactors are unavailable and organic synthesis research remains in the pre-1980 era.

In this project, we tried to step forward by saving time and increasing yields by using a domestic

microwave oven with a new specially-constructed fit-in ice condenser. For assessment purposes, esterification reactions (Scheme 1) were carried for Diclofenac, Ibuprofen, Indomethacin, and salicylic acid (Figure 1).



Scheme 1. Acid-catalyzed esterification reaction

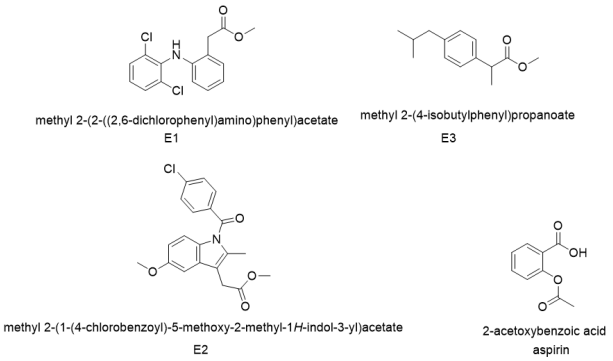


Figure 1. Synthesized esters

Materials and Methods

Materials

Diclofenac sodium, Indomethacin, Ibuprofen (were obtained from Amipharma laboratories and were used without further purification), Salicylic acid, Ethanol absolute, Methanol specially dried, Acetic anhydride, Glacial acetic acid and Sulfuric acid.

Equipment

Domestic microwave oven (LG 700 W maximum power), specially constructed fit-in ice cooling condenser (borosilicate glass, thickness 3mm), flat bottom flask.

Experimental details

Conventional synthesis (thermal catalysis)

Diclofenac acid (5.010 g, 0.0169 mole) and methanol (150 ml) were placed in a round bottom flask, sulfuric acid (4.5 ml) was added. The mixture was heated at reflux for 6 h in a heating mantle, methanol was evaporated overnight at room temperature and the acid was neutralized by addition of $NaHCO_3$ (1 M). The ester was filtered off and dried at room temperature, TLC was carried to ensure purity.

Salicylic acid (2.005 g, 0.0145 mole) and acetic anhydride: glacial acetic acid mixture (20 ml, 1:1) were added into a round bottom flask and heated under reflux for 90 min, the mixture was poured into iced water, the ester was filtered off and dried at 100°C in an electric oven. The ferric chloride test REF was conducted for purity testing.

DMO Method

Diclofenac sodium (5.016 g, 0.0169 mol); Indomethacin (3.005 g, 0.0084 mol) and Ibuprofen (3.017g, 0.0146 mol) were transferred into separate flat bottom flasks, methanol (10 ml) was added and c.H_2SO_4 (0.5 ml) added dropwise. The flask was fitted with the fit-in ice cooling condenser and placed inside a domestic microwave oven, after reaction completion, neutralization with sodium bicarbonate and drying took place, TLC was performed to assess purity.

Acetylsalicylic acid was synthesized as in the conventional method above.

Results and Discussions

The fit-in ice condenser (Figure 2), when connected with a flat bottom flask, fits inside a domestic microwave oven (DMO) and can stand on its own. It was made of borosilicate glass, the thickness of 3mm. The condenser composes of three parts (Figure 3): external walls, internal walls, and drainage joint that attach to both pieces, all pieces join connect using a Quickfit™ joint system (Figure 4).

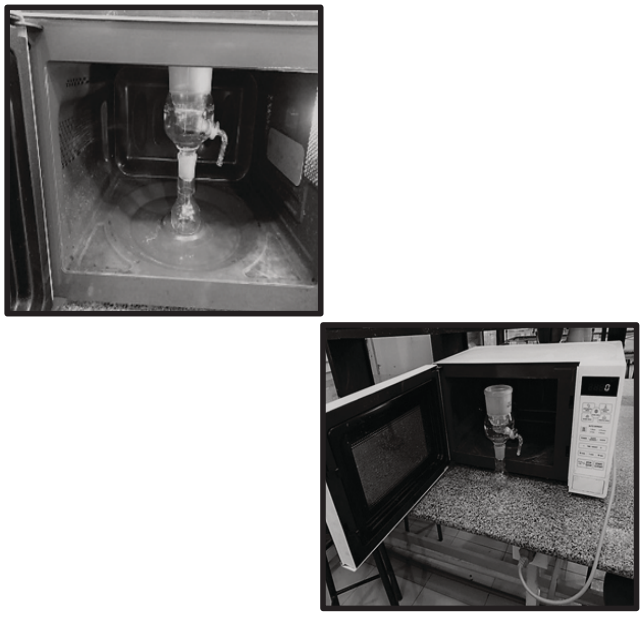


Figure 2. Microwave oven with the fit-in condenser and flat bottom flask

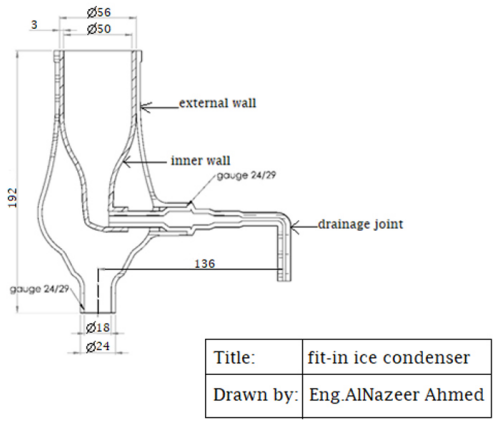


Figure 3. 2D section of the fit-in ice condenser. Inner wall for ice placement, external walls that form a cavity for reactants sealing and a drainage joint to drain melted water to increase the efficacy of cooling

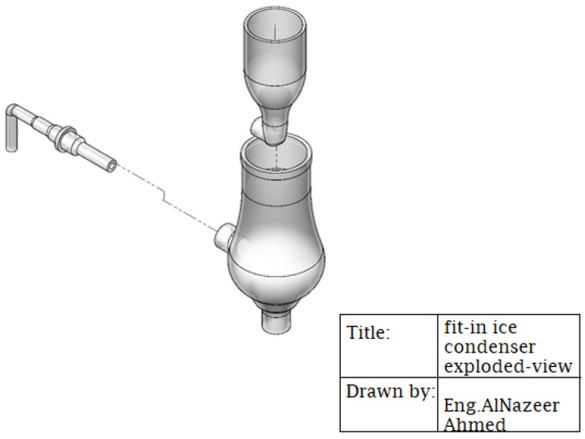
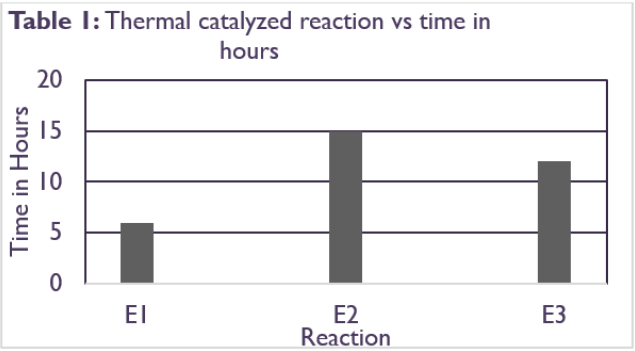


Figure 4: 3D view to show the assembly of condenser parts

The coolant in this condenser is ice as the ice full condenser can take 3 min at 700 W to meltdown, while water goes from 25 °C to 100 °C just in 30 seconds. Microwave radiations will heat only compounds with a dipole moment as they will tend to resonate with the changing electric field of the electromagnetic wave, this continuous rotation will lead to friction and rapid heat generation. Ice has restrictions to movement in comparison with liquid water and will melt in a slower rate. When ice melts, liquid water exits through the drainage joint into a receiving beaker to prevent its accumulation near solid ice, to increase melting time of the ice [1-3].

Conventional synthesis of E1 required continuous reflux for 6 h, to give a yield 98% while the same reaction under DMO catalysis gave 92% E1 in just 4 min. A report of a similar method for E1 with 5 h reflux gave a yield of 88% [4], while a different method gave 95% in 12 h [5].



No data was available for yield comparison between the conventional method and DMO synthesis for E2 and E3, but it is evident that the use of DMO gave good yields of 76% and 96% respectively in less than 10 min, while a reported method for the synthesis of E3 suggested overnight wait [6]. DMO synthesis of aspirin gave 66% in just 2 min, which is a good yield in comparison to 72% in 1.5 hr.

Table 2: Conversion efficiency (yields and reaction times) of model reactions in a DMO

Material	DMO Time min	Yield%
E1	4	92
E2	8	76
E3	7.5	96
Aspirin	2	66

Conclusion

Although some do not recommend the use of DMO in organic synthesis, due to lack of controllability and high safety risk, but the use of domestic microwave oven in organic synthesis is still possible and under suitable conditions DMO can help in substituting microwave reactors when not available. In developing countries when there

Conclusion

Although some do not recommend the use of DMO in organic synthesis, due to lack of controllability and high safety risk, but the use of domestic microwave oven in organic synthesis is still possible and under suitable conditions DMO can help in substituting microwave reactors when not available. In developing countries when there is lack of microwave reactors, and there is need for speedy and high yield reactions, DMO with suitable cooling system could be used efficiently. DMO use can reduce time, increase yield and spare solvents.

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Conflicts of interest

None declared.

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