

Rapid Communication

Zeolite-HY : A selective and efficient catalyst for the synthesis of amides under microwave irradiations

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An efficient and selective method for the conversion of various acids into their corresponding amides in the presence of zeolite under microwave irradiation is described. The reaction proceeds efficiently at ambient pressure in high yields.

Amide moiety is an important constituent of many biologically significant compounds¹. It's synthesis is usually accomplished by treatment of either ammonia or a primary or secondary amine with an acylating agent^{1,2}. Carbodiimides are frequently used as condensing agent³, however, the formation of N-acylureas and carboxylic anhydrides, occurring as side reactions. Direct conversion of esters to amides is potentially a useful synthetic operation, but the practical application of this method has been somewhat limited for a number of reasons⁴. In general, aminolysis of esters requires high temperature and/or long reaction periods⁵ and the strong alkali metal catalysts sometimes used⁶⁻⁹ are not compatible with sensitive functionality. Milder catalysts such as 2-pyridone¹⁰ and borontribromide¹¹ have been reported, but the generality of these reagents has not been tested. Some work has also appeared on the use of tin and titanium amides in this transformation¹². But careful scrutiny of the reaction procedure reveals some shortcomings in most of the procedures. Therefore, there is still merit in developing a catalytic procedure for the preparation of amides using efficient and inexpensive reagents. Moreover, in recent years considerable resurgence of interest in the area of zeolite induced organic transformations¹³ have figured prominently for their remarkable catalytic properties. Several methods using this catalyst, e.g. thioacetalization of carbonyl compounds, sulphoxidation of thioethers, deketalisation and oxidative cleavage of tosylhydrazones, have been investigated¹⁴. Herein we wish to report that zeolite-HY effects the formation of various saturated and unsaturated amides in excellent yields under microwave irradiation and with an extremely simple work-up, which makes it a reagent of practical synthetic value. The

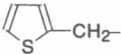

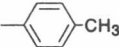
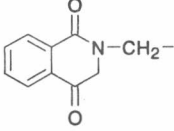
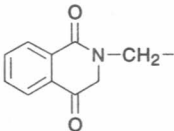
reaction is fairly general, facile and efficient and is devoid of any side products emanating from functional groups present.

In a typical case, zeolite-HY was added to a mixture of acetic acid and aniline in an Erlenmeyer flask and placed in a commercial microwave oven operating at 2450 MHz frequency and irradiated for 40 min. The reaction mixture was allowed to attain room temperature, treated with methanol and filtered off. After usual work-up acetanilide [mp 114 °C (lit¹⁵ mp 114 °C)] was obtained in 93% yield exclusively and there was no evidence for the formation of any side products. Similar treatment of other substrates gave the corresponding amides **3** in 80-96% yields (**Scheme I**; **Table I**). All the compounds obtained were characterised by IR and ¹H NMR spectroscopy and finally by comparison with authentic samples. It is interesting to note that this reaction is not equally effective when carried out without using microwave irradiation and the conversion was only 25% (in the case of entry 1). Similarly, the reaction did not proceed at all when performed without zeolite-HY. The optimum results were obtained when equimolar amounts of the substrates were reacted in the presence of zeolite-HY under microwave irradiation. Furthermore, in order to show the preparative utility of this method, it was applied to the synthesis of alkenamides. Thus, the reaction of crotonic acid with aniline was carried out in the presence of zeolite-HY under microwave irradiation. After usual work-up N-phenyl-2-butenamide, mp 111-113 °C (lit¹⁶ mp 112-114 °C), was obtained in 85% yield. Similarly, phenylpropionic acid anilide was obtained in 80% yields (cf. **Table I**).



Scheme I

Table I— Zeolite-HY catalysed formation of various amides under microwave irradiation

Entry	R ¹	R ²	Reaction period (min)	Yield ^a (%)	mp °C	Lit mp °C
1	Me	Ph	40	93	114	114 ¹⁵
2	PhCH=CH-	Ph	45	90	152-53	152 ¹⁷
3		Ph	60	97	115-17	116-17 ¹⁷
4	Ph	Ph	30	95	162-63	163 ¹⁷
5			60	94	131-33	130-32 ¹⁷
6		Ph	30	96	228-30	230-31 ¹⁸
7		-CH ₂ -Ph	60	80	217-18	216-18 ¹⁸
8	CH ₂ =CH-	Ph	50	85	104-05	104-05 ¹⁶
9	CH ₃ CH=CH-	Ph	55	80	111-13	112-14 ¹⁶
10	CH ₂ =CH-	<i>c</i> -C ₆ H ₁₁	60	82	106-07	107-08 ¹⁶
11	CH ₃ CH=CH-	<i>c</i> -C ₆ H ₁₁	55	80	118-19	117-19 ¹⁶
12	PhC≡C-	Ph	60	85	125-26	125-26 ¹⁵

^a Refers to the yield of pure isolated product.

In conclusion, this zeolite catalysed new method of amide formation without any solvent under microwave irradiation offers significant improvements over the existing procedures and will make a useful and important addition to the present methodologies. Also, this simple and easily reproducible technique affords various products in shorter reaction period, with excellent yields without involvement of toxic and expensive material and without the formation of any undesirable side products, than the classical homogeneous reaction in solvents.

Experimental Section

General. Melting points were determined on a Buchi melting point apparatus and are uncorrected. IR spectra

were recorded in KBr discs on a Perkin-Elmer 237B IR spectrophotometer. Microanalyses were performed on a Perkin-Elmer 240C analyser. 90 MHz ¹H NMR spectra were recorded at RSIC Shillong. Mass spectra were recorded on an AEIMS 30 instrument by the electron impact method. Solvents were dried according to standard procedures. Light petroleum is the fraction with boiling point 60-80 °C. All reagents were of commercial quality from freshly opened containers and were purchased from Aldrich Chemical Co. and used without further purification.

General procedure for the preparation of saturated and unsaturated amides: Zeolite-HY (0.5g) was added to a mixture of acetic acid (10 mmoles, 0.6g) and aniline (10 mmoles, 0.93g) in an Erlenmeyer flask and placed in

a commercial microwave oven operating at 2450 MHz frequency and irradiated for 40 min. The reaction mixture was allowed to attain room temperature and treated with methanol and filtered off. Removal of solvent under vacuum at water-bath temperature afforded acetanilide (entry 1), mp 114 °C (lit¹⁵ mp 114 °C), in 93% yield.

Similar treatment of other substrates gave the corresponding amides **3** in 80-96% yields (cf. **Table I**). All the compounds prepared were characterised by IR and ¹H NMR spectroscopy and finally by comparison with authentic samples.

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