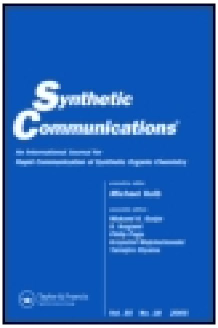

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Base-Catalysed Isomerization of Eugenol: Solvent-Free Conditions and Microwave Activation

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BASE-CATALYSED ISOMERIZATION OF EUGENOL : SOLVENT-FREE CONDITIONS AND MICROWAVE ACTIVATION

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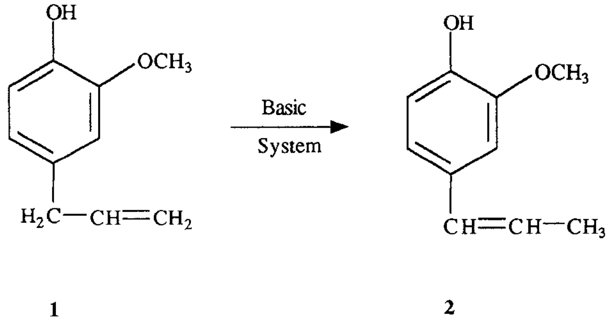
Abstract :

Isomerization of eugenol can be efficiently performed using 2.2 mol. equiv. of KOtBu and catalytic amount of transfer agent in the absence of solvent. The best conditions (94 % within 18 minutes) were obtained in a focused open-vessel Maxidigest MX 350 microwave reactor.

Isoeugenol **2** is a starting material of great interest in chemistry of perfumes and flavours. Its oxidation leads to vanillin which is probably one of the most popular flavours in agroalimentary chemistry. Isoeugenol can be itself obtained from eugenol **1** by a base-catalysed isomerization reaction, the starting eugenol being a natural product available in appreciable quantities from a variety of essential oils (cloves, cinnamon-tree or pimento leaves)[1]



Yields for this isomerization are generally modest to good and experimental conditions are relatively harsh[2]. Very recently, using KF impregnated on alumina as base[3], this reaction was carried out at 200°C within 90 minutes with a satisfactory yield (78 %) in the presence of ethylene glycol as solvent.

During the course of our studies of isomerization under solvent-free conditions, we have considered the behaviour of safrole and ethyleugenol using KOH or KOtBu and catalytic amounts of transfer agent under solid-liquid phase transfer catalysis (PTC) in the absence of solvent[4]. As eugenol isomerization into isoeugenol needs further improvements, we first extrapolated our previous conditions to this case. Results are given in Table 1.

The best present result under PTC conditions without solvent is that using KOtBu-Aliquat. Yields remain rather limited (73 %) and experimental conditions still harsh (90 minutes at 200°C).

Consequently, we tested the possibility of assistance by several additives including amines and amino-alcohols (Table 2).

The effect of amine or amino-alcohol addition is very significant as it results in the isomerization. Their role is not clearly established. However, one can evoke

Table 1

Isomerization of **1** under solvent-free conditions at 200°C within 90 min

Basic System	Yield (GC) % **2**
KF-Alumina (20 eq) in EG [a]	78
in "dry media" [b]	10
KOH (2.2 eq)	< 2
KOH (2.2 eq) + Aliquat (5 %)	60
KOtBu (2.2 eq)	< 2
KOtBu (2.2 eq) + Aliquat (5 %)	73

a) ref. 3 ; EG = ethylene glycol

b) ref. 5

Table 2

Isomerization of **1** (10 mmoles) in the absence of solvent by KOtBu (2.4 eq)

Additive effects at 150°C within 24 hours

Additive	(mol. eq)	Yield % **2**
EG	1.5	12
MDEA[a]	1.2	87
DEA [b]	1.2	86
DEA	2.4	88
PYR [c]	1.2	76
PYR	2.4	90
QUIN [d]	2.4	78

a) N-methyl diethanolamine

b) Diethanolamine

c) Pyridine

d) Quinoline

the possibility of intervention of ammonium salts by abstraction of a proton to eugenol, which subsequently act as a phase transfer catalyst. Such behaviour was described in ethoxylation of phenols where they act as co-catalysts in a PTC process[6].

Finally, as these reactions require rather long times at high temperatures (24 h at 150°C or 90 min at 200°C), we investigated the microwave irradiation which has been shown to be particularly adequat for this type of conditions. This method could induce rapid and efficient reactions, especially in the absence of solvent, either using supported reagents on mineral oxides[7] or PTC conditions[8].

Two kinds of microwave reactors were used to this purpose :

a) a domestic (mutimode system) Philips Whirlpool AT 5964

b) a focused microwave digester[9] (monomode system) Prolabo Maxidigest MX 350.

We choose to test the behaviour of KOH or KOtBu/Aliquat systems as they are more potentially useful than those using rather volatile and more expensive amines. First experiments were performed in the domestic oven using crushed KOH in various amounts in the presence of 5 % Aliquat 336. Results are given in Table 3.

The best result (65 %) was obtained with 1.5 mol. equiv. of KOH for 3 minutes with an incident power of 600 W. However, in this case, the conversion is much better (90 %), signifying important loss of products due to the instability of 2 under microwave irradiation.

In order to avoid this inconvenience which is essentially connected to the heterogeneity of electromagnetic field and to a too strong power, reactions were performed in the monomode system.Results are given in Table 4.

The best results we obtained using KOH is enhanced up to 88 % as compared to 65 % in the multimode oven. Using KOtBu it can be increased to 94

Table 3

Isomerization of **1** using KOH + Aliquat (5 %) in a domestic microwave oven

KOH	Microwave		Yields		Final a) Temperature
molar equiv.	Power (W)	Time (min)	% **2**	% **1**	
1.4	750	3	26	34	195
1.6	"	"	34	20	193
2.0	"	"	40	5	192
1.5	600	2	34	60	177
1.5	"	3	**65**	10	194
1.5	"	4	44	23	209
2.0	100	10	49	7	215

a) Evaluated by a Luxtron optical fibre thermometer or by introducing a digital thermometer at the end of the irradiation

Table 4

Isomerization of **1** using 2.2 mol. equiv. of base + Aliquat (5 %)

in the Maxidigest MX 350 reactor

Base	Microwave		Yields		Final a) Temperature
	Power (W)	Time (min)	% **2**	% **1**	
KOH	30	12	74	19	188
	45	8	79	15	190
	45	12	**88**	–	198
	60	6	52	45	170
	60	12	63	–	210
KOtBu	45	12	87	12	185
	45	18	**94**	–	192

%. This improvement presumably arises from a better efficiency in wave-material interactions due to the focused system and the subsequent use of lower incident power. This conclusion underlines once more the special efficacy and potentiality of this system[10-12].

This method, thus constitutes a considerable improvement in eugenol isomerization when compared to classical ones.

Experimental Part

A mixture of eugenol (15 mmol), crushed potassium hydroxide or terbutoxide (33 mmol.), the phase transfer catalyst (0.75 mmol) was placed either in a beaker in a domestic oven or in a Pyrex tube introduced into the Maxidigest MX 350 Prolabo microwave reactor fitted with a rotational system. Microwave irradiation was carried out in the conditions described in Tables 3 and 4. The mixture was cooled to ambient temperature. After elution with diethyl ether (50 ml) and subsequent filtration on Florisil, the organic products were analysed by GC using an internal standard (capillary column OV1 15 m at 100°C ; retention times **1** : 3.75 min, **2Z** : 4.85 min ; **2E** : 5.97 min - E/Z $\simeq$ 90-10) and characterized by ^{1}H NMR spectroscopy by comparison with authentic samples.

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