

Sodium selenite-dimethylsulfoxide: a highly efficient reagent for dehydrogenation

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Sodium selenite in dimethylsulfoxide is a highly efficient reagent for dehydrogenation reactions and can be used under both thermal as well as microwave irradiation conditions. Using this reagent benzoines have been dehydrogenated to benzils, flavanones to flavones and 2'-hydroxy chalcones have been converted into flavones by cyclodehydrogenation.

Keywords: sodium selenite, dimethylsulfoxide, benzoines, benzils, flavanones, flavones, 2'-hydroxy chalcones

Dehydrogenation is one of the common reactions involved in synthetic organic chemistry. Some of the important reagents used for dehydrogenation include ceric ammonium nitrate,¹ selenium dioxide,² seleniumdioxide-DMSO,³ triphenylmethyl perchlorate,⁴ DDQ,⁵ Pd on carbon,⁶ N-chlorosuccinimide,⁷ H₂O₂- NaOH⁸ and InBr₃.⁹ Selenium dioxide, the reagent which has been used for dehydrogenation in number of compounds, is quite hazardous due to its volatility. Sodium selenite, in which selenium is present in the + 4 oxidation state, has not been exploited as an oxidising agent perhaps due to its insolubility in the common organic solvents being used for the reactions. We have observed that sodium selenite acts as an excellent dehydrogenating agent in dimethylsulfoxide medium. SeO₂ is volatile but selenium and sodium selenite are not that volatile,^{10,11} and thus sodium selenite not as harmful as selenium dioxide and we wish to report the utility of this efficient dehydrogenating reagent in the present work. It is possible, however, that its reduction product is volatile. Dehydrogenation of benzoines was chosen as the first example and these were converted into benzils **1a–c** by heating with sodium selenite in dimethylsulfoxide at 140°C under anhydrous conditions. It is well known that a number of organic reactions when carried out using microwave irradiations (M.W.), are markedly improved in terms of temperature needed and time taken.^{12,13} Continuous microwave radiation could not be

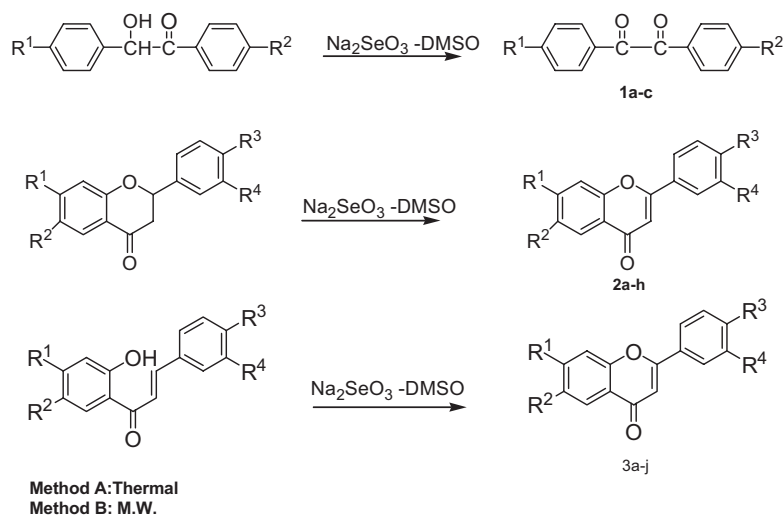
applied to these systems due to rapid boiling of the solutions; hence, exposure was given intermittently (Table 1). Thus the above reaction was carried out by using microwave irradiation and the reaction was found to be completed (TLC) in 2.5 min. at 100°C. Flavanones were the next class of naturally occurring compounds chosen for the study and eight compounds of this class with substituents at various positions could be successfully dehydrogenated to flavones **2a–h** with sodium selenite in dimethylsulfoxide under thermal as well as under microwave conditions (Table 1).

Encouraged by the above results, the cyclodehydrogenation of 2'-hydroxychalcones was studied. This reaction is considered to be one of the important reactions in flavanoid chemistry for the direct synthesis of flavones from 2'-hydroxychalcones. Flavones constitute a large class of natural products. Synthesis of flavones and their derivatives has attracted considerable attention due to their significant biocidal,¹⁴ pharmaceutical,¹⁵ antioxidant,¹⁶ anti-anxiolytic,¹⁷ anticancer¹⁸ and anti-inflammatory effects.¹⁹ This conversion is usually carried out by heating 2'-hydroxychalcones with selenium dioxide²⁰ in biphenyl ether. Other reagents that have been used include sodium periodate,²¹ iodine,²² iodine-DMSO,²³ Pd-black²⁴ or Pd(II),²⁵ DDQ²⁶ and organic disulfides.²⁷ These reactions usually require long reaction periods (20–40 h) or the reaction is accompanied by formation of other products such as aurones

Table 1 Dehydrogenation of benzoines to benzils **1a–c**, flavanones to flavones **2a–h** and cyclodehydrogenation of 2'-hydroxy chalcones to flavones **3a–j**

Compd	R ¹	R ²	R ³	R ⁴	Method A			Method B			Lit. M.p. /°C
					Time/h	Yield/%	M.p./°C	Time/min	Yield/%	M.p. /°C	
1a	H	H	H	H	1.5	80	94	1.5	90	95	95 ²⁸
1b	OCH ₃	OCH ₃	H	H	1.5	80	129	1.5	85	130	132–133 ²⁸
1c	CH ₃	CH ₃	H	H	2.0	85	100	2.0	90	100	102 ²⁸
2a	H	H	H	H	3.0	80	97–98	2.0	85	97–98	97–98 ²⁹
2b	H	H	OCH ₃	H	4.0	65	155	3.0	75	156	157–158 ³⁰
2c	OCH ₃	H	H	H	2.5	70	109	2.0	76	108–109	110–111 ³²
2d	OCH ₃	H	OCH ₃	H	3.0	60	142	2.5	75	143	143–144 ³¹
2e	H	CH ₃	H	H	3.0	76	120–121	1.5	85	119–120	122 ²⁹
2f	H	CH ₃	OCH ₃	H	4.0	70	168	2.5	80	168–169	170 ³¹
2g	H	H	H	OCH ₃	2.5	70	128–129	2.5	75	127–128	129–130 ²⁷
2h	H	H	CH ₃	H	3.0	80	109–110	2.0	85	110–111	111–112 ²⁷
3a	H	H	H	H	3.0	80	97–98	2.5	85	96–97	97–98 ²⁹
3b	H	H	OCH ₃	H	2.5	75	156–157	2.5	80	156–158	157–158 ³⁰
3c	H	CH ₃	H	H	1.5	70	120–121	1.5	75	120–121	122 ²⁹
3d	H	CH ₃	OCH ₃	H	1.5	75	168–169	2.0	80	169–170	170 ³¹
3e	OCH ₃	H	H	H	4.0	80	108–110	2.5	80	108–109	110–111 ³²
3f	OCH ₃	H	OCH ₃	H	4.0	70	142–143	3.0	75	142–144	143–144 ³¹
3g	H	H	CH ₃	H	2.5	75	110–112	1.0	75	109–110	111–112 ³³
3h	H	H	H	OCH ₃	2.5	80	126–128	2.0	80	128–129	129–130 ²⁷
3i	H	OCH ₃	H	H	2.0	70	150–152	2.5	80	151–153	154 ³⁴
3j	H	OCH ₃	OCH ₃	H	3.0	75	193–194	1.5	80	192–193	194–195 ³⁵

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Scheme 1

and flavanones. The 2'-hydroxychalcone was thus heated with sodium selenite in dimethylsulfoxide at 140°C and the flavone was obtained as a sole product after 3 h. The same reaction was when repeated under microwave irradiations. The reaction was found to be completed in 2.5 min. (TLC) and flavone was obtained in 85% yield (Table 1). Using this method 10 2'-hydroxychalcones were converted into flavones **3a–j**. The identities of the products were confirmed from their ^1H NMR spectroscopic data and by direct comparison with authentic samples (CO-IR).

In conclusion, it can be stated that sodium selenite in dimethylsulfoxide is a highly efficient reagent which can be used for dehydrogenation of various compounds under thermal as well as microwave conditions.

Experimental

The reactions were carried out in a domestic microwave oven (Samsung, output energy 900W, frequency 2450 MHz, with temperature control arrangement model No.CE118KF using 50% power for all experiments). The identities of the products were confirmed from their ^1H NMR spectroscopic data and direct comparison with authentic samples (CO-IR).

CAUTION: Care should be taken when heating dimethylsulfoxide by microwave irradiation due to its high polarity and heat capacity.

General procedure for dehydrogenation

Method A (Thermal): The substrate (0.05 mol) in dimethylsulfoxide (4 ml) and sodium selenite (0.05 mole) under anhydrous conditions using a calcium chloride guard tube were heated on an oil bath maintained at 140°C for the specified period and the completion of the reaction was monitored by TLC. After disappearance of the starting material, the reaction mixture was cooled, and diluted with ice cold water (50 ml) and extracted with diethyl ether (3 × 30 ml). The organic layer was washed with water and dried over Na_2SO_4 . The solvent was removed by distillation and the residue was crystallised from aqueous methanol to afford the product.

Method B (M.W.): A solution of substrate (0.02 mol) in dimethylsulfoxide (2 ml) and sodium selenite (0.02 mole) in a loosely stoppered 20 ml round bottom flask was irradiated with microwave irradiation (450 W) setting the microwave oven temperature at 100°C for the specified period. The completion of the reaction was monitored by TLC. The reaction mixture was worked up as described in Method A to give the product.

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