1,4-Diazabicyclo[2.2.2]octane 1,4-Bis(oxide)-Bis(hydrogen peroxide)/MCl_x as a Novel Heterogeneous System for the Oxidation of Urazoles under Mild Conditions

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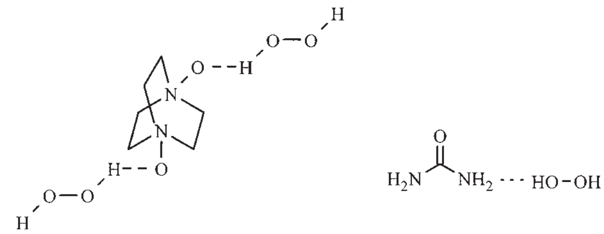
A combination of inorganic hydrolyzable chloride salts and 1,4-diazabicyclo[2.2.2]octane 1,4-bis(oxide)-bis(hydrogen peroxide), DABCO-DNODP, in the presence of wet SiO_2 is used as an effective oxidizing agent for the oxidation of urazoles and bis-urazoles to their corresponding triazolinediones under mild and heterogeneous conditions with good to excellent yields.

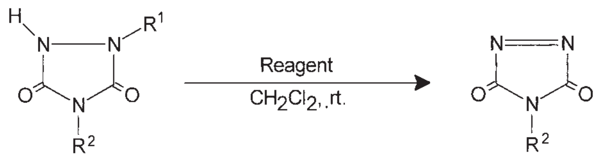
4-Substituted-3*H*-1,2,4-triazole-3,5(4*H*)-diones (TADs) are notable for their ability to participate in a wide range of reactions.[1] All known methods for the synthesis of these compounds require oxidation of the corresponding 1,2,4-triazolidine-3,5-diones (**1**, **3**), more commonly known as urazoles. Although a wide variety of reagents are capable of effecting the urazoles oxidations,[2] this transformation remains capricious because these compounds are very sensitive to the oxidizing agents and reaction conditions. Because of the advantages of heterogeneous reagent systems, there is interest in finding a heterogeneous system for urazole oxidation. Urea–hydrogen peroxide (1/1) addition compound (UHP, **II**) was a suitable oxidizing agent for conversion of urazoles and bis-urazoles to the corresponding triazolinediones,[2] but we observed that 4-aryl substituted triazolinediones gave stable complexes with cations of chloride salts and we couldn't isolate the products satisfactorily. Therefore we tried to conduct similar reactions with another in situ peroxide generator; 1,4-Diazabicyclo[2.2.2]octane 1,4-bis(oxide)-bis(hydrogen peroxide), (DABCO-DNODP) (**I**; Chart 1). Although DABCO-DNODP was fully characterized,[3] we did not find any report on its application in organic synthesis.

In this paper we wish to report a simple and convenient method for the effective conversion of urazoles and bis-urazoles **1** and **3** to their corresponding triazolinediones **2** and **4** by using a DABCO-DNODP/MCl_x system under mild and heterogeneous conditions (Schemes 1 and 2). Using this new system, oxidation of all urazoles [i.e. 4-alkylurazoles **1**



I **II**

Chart 1.

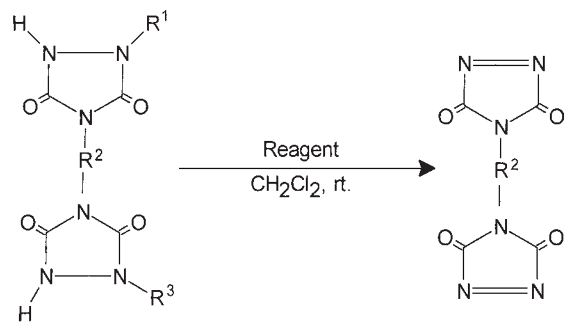


1 **2**

Reagent: DABCO-DNODP (**I**)/MCl_x/Wet SiO_2

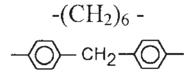
1	R^1	R^2
a	H	Me
b	H	Et
c	Na	*n*-Pr
d	H	*n*-Bu
e	H	Cyclohexyl
f	H	Ph
g	H	4-Cl-C_6H_4
h	H	4-NO_2-C_6H_4
i	H	3,4-$Cl_2C_6H_3$

Scheme 1.



3 **4**

Reagent: DABCO-DNODP (**I**)/MCl_x/Wet SiO_2

3	R^1	R^2	R^3
a	Na	-$(CH_2)_6$-	Na
b	H		H

Scheme 2.

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Table 1. Oxidation of Urazoles **1** and Bis-Urazoles **3** to Their Corresponding Triazolinediones **2** and **4** with a Combination of DABCO-DNODP (**I**), Chloride Salt [$AlCl_3$ (**III**), $ZrCl_4$ (**IV**)] and Wet SiO_2 (50% w/w) in Dichloromethane at Room Temperature

Urazole or (bis)	Product[a]	Reagent/Substrate[b] I	III	IV	Time /h	Yield[c] /%	mp /°C
1a	**2a**	2.5	1	—	1	100[d]	97–99
1a	**2a**	2.75	—	1	1	100[d]	97–99
1b	**2b**	2.5	1	—	1	100[d]	54–56
1b	**2b**	2.75	—	1	1	100[d]	54–56
1c	**2c**	2.5	1	—	1	81	42–54
1c	**2c**	2.75	—	1	1	99	42–54
1d	**2d**	2.5	1	—	1	84	43–45
1d	**2d**	2.75	—	1	1	90	43–45
1e	**2e**	2.5	1	—	1	98	97–98
1e	**2e**	2.75	—	1	1	98	97–98
1f	**2f**	3	1.5	—	1	95	168–175
1f	**2f**	2.75	—	1	1	95	168–175
1g	**2g**	3	1.5	—	1	95	134–135
1g	**2g**	2.75	—	1	1	97	134–135
1h	**2h**	3	1.5	—	1	85	125–126
1h	**2h**	2.75	—	1	1	82	125–126
1i	**2i**	3	1.5	—	1	80	110–113
1i	**2i**	2.75	—	1	1	81	110–113
3a	**4a**	4	2	—	1	85	145–150
3a	**4a**	4	—	1.5	1	90	145–150
3b	**4b**[e]	4	2	—	1	80	182–185(dec.)[f]
3b	**4b**[e]	4	—	1.5	1	95	182–185(dec.)[f]

a) All of the products are known compounds and were characterized by comparison of their spectral data and physical properties with authentic samples.[1–3] b) Wet SiO_2:substrate (mono) (0.4 g:1 mmol) and wet SiO_2:substrate (bis) (1 g:1 mmol). c) Isolated yields. d) Conversion. e) 60 mL of solvent for one mmol of substrate must be used. f) Decomposition point.

and 4-arylurazoles **3**] was performed successfully (Schemes 1 and 2, Table 1). The oxidation reactions were performed under mild and completely heterogeneous conditions at room temperature with good to excellent yields (Table 1). The reactions were readily promoted by stirring the starting materials in CH_2Cl_2 at room temperature for 1 hour, and the triazolinedione **2** or bis-triazolinedione **4** could be isolated by simple filtration and evaporation of the solvent.

In conclusion, practical and efficient oxidations of urazoles and bis-urazoles have been achieved by the new methodology described. The system can be used with complete safety without any special precautions, a very important consideration.

Experimental

General. DABCO-DNODP (**I**), was synthesized according to the reported procedure,[3] with a slight modification. Here, we used 30% H_2O_2 instead of 90%. All urazoles and bis-urazoles were synthesized according to our previously reported procedures.[1]

Oxidation of 4-cyclohexylurazole (1e) to 4-cyclohexyl-3*H*-1,2,4-triazole-3,5(4*H*)-dione (2e) with DABCO-DNODP/MCl$_x$ system, a typical procedure. A suspension of **1e** (0.366 g, 2 mmol), **I** (1.060 g, 5 mmol), wet SiO_2 (50% w/w) (0.4 g) and $AlCl_3$ (0.268 g, 2 mmol) in dichloromethane (20 mL) was stirred at room temperature for 1 h and then filtered. Anhydrous Na_2SO_4 (3 g) was added to the filtrate. After 15 minutes, the resulting mixture was filtered. Dichloromethane was removed using a water bath (40–50 °C) by simple distillation. The yield was 0.354 g (98%) of crystalline red solid **2e**, mp 97–98 °C [Lit[2] mp 95–96 °C].

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