

reduce the reaction time, the reaction was carried out under ultrasonication to afford the product **2a** in 30 minutes (Table 1). The remarkable reactivity of Amberlyst-15 gave us impetus to study it further in reaction with other α -diazocarbonyl compounds in a heterogeneous manner.

Initially we studied other aromatic compounds **1b–e** and aliphatic diazo compounds **1f,g** which afforded the respective α -hydroxy ketones **2b–g** both room temperature and under ultrasonication. These reactions were also carried out in acetone as a solvent for all the diazo compounds **1**, which afforded **2** in comparable yield. The resulting intermediate undergoes an O–H insertion reaction¹⁶ to give the α -hydroxy ketone **2**. Moreover, the α -hydroxy ketones are versatile intermediates in the synthesis of several natural products such as frontaline.¹⁷

Encouraged by these results with aromatic compounds; we subsequently investigated the reaction of various

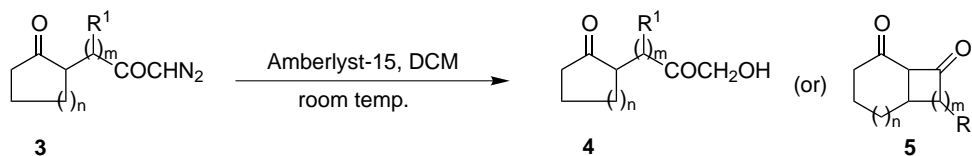
alicyclic α -diazocarbonyl compounds (Scheme 2) with Amberlyst-15, which afforded unexpected results. The reaction of diazo compounds **3a–c** having a two/three-carbon chain length in the presence of Amberlyst-15 resulted in the corresponding α -hydroxy ketones¹⁵ (Table 2). In the case of diazo compound **3d**, having a three-carbon chain length tethered to a cyclohexanone ring system, reaction with Amberlyst-15 furnished the 1,3-dione **5d** instead of the corresponding α -hydroxy ketone **4d**. We confirmed this curious cyclization by performing the reaction with diazo compound **3e**. It is interesting to note that these bicycloalkane-1,3-diones **5** have also been synthesized from diazo ketones **3d,e** using $\text{SnCl}_2^{4b}/\text{TiCl}_4^5$ as a catalyst.

We were further interested in studying the effect of ring size with only one carbon in the chain in the α -diazocarbonyl compounds. Diazo carbonyl compounds **1, 3** and **6** involved in this work were prepared based on literature precedents.^{1,18} Then, we extended our investi-

Table 1. Reaction of aromatic α -diazocarbonyl compounds **1a–g** with Amberlyst-15

Substrate	R ¹	R ²	R ³	n	Time		Yield ^a (%)
					Room temp. (h)	Ultrasonication (min)	
1a	OMe	H	H	0	8	30	82
1b	H	H	H	0	7	20	77
1c	Me	H	H	0	5.5	20	92
1d	H	Me	H	0	6	25	80
1e	H	-CH=CH-CH=CH-	H	0	7	35	79
1f	H	H	H	1	7	30	75
1g	H	H	H	2	6	25	76

^a Yields (unoptimized) refer to isolated and chromatographically pure compounds **2**.

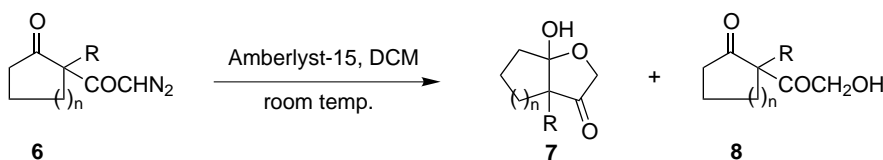


Scheme 2.

Table 2. Reaction of alicyclic α -diazocarbonyl compounds with Amberlyst-15

Substrate	R ¹	n	m	Time (h)	Yield ^b of 4 ^c	Yield ^b of 5 ^c
3a	H	1	1	5	76	–
3b	H	1	2	5	82	–
3c	H	2	1	5	85	–
3d	H	2	2	2.5	–	71 ^{4b,5}
3e	Me	2	2	6	–	69

^b Yields (unoptimized) refer to isolated and chromatographically pure compounds **4** and **5**.



Scheme 3.

Table 3. Fused 3-furanones ring systems **7** produced via Scheme 3

Substrate	R	n	Time (h)	Yield ^c of 7%	Yield ^c of 8%
6a	Me	1	1	39	38
6b	CH ₂ CH=CH ₂	1	1	34	35
6c	Me	2	0.5	87	–
6d	CH ₂ CH=CH ₂	2	0.5	74	–

^c Yields (unoptimized) refer to isolated and chromatographically pure compounds **7** and **8**.

gation on diazo compounds **6a–d** (Scheme 3). Treatment of diazo ketones **6a,b** with Amberlyst-15 resulted in the respective novel fused 3-furanone skeleton **7a,b** and α -hydroxy ketones **8a,b**. However, in the reaction of an α -diazo ketone tethered to a cyclohexanone ring **6c,d** the corresponding fused 3-furanones **7c,d**¹⁵ were formed (Table 3). The reason may be the formation of a favorable 6,5-fused ring system **7c,d** rather than the strained 5,5-fused ring system **7a,b** under the experimental conditions. It is worth noting that the fused 3-furanone skeleton is present in many natural products such as avermectin B.¹⁹ It may also be noted that the olefin moiety present in the diazo compounds **6b,d** stayed intact under the reaction conditions.

In summary, the reaction of various α -diazo carbonyl compounds with a solid ionic matrix, Amberlyst-15 under mild heterogeneous conditions furnished α -hydroxy ketones, novel fused 3-furanones and bicycloalkane-1,3-diones. The mild reaction conditions together with the heterogeneous manner makes the use of Amberlyst-15 an important alternative to classic acidic catalysis and other methods, since both by-products and aqueous work-up are avoided.

Acknowledgements

This research was supported by the CSIR, Young Scientist Scheme and partly by the Department of Science and Technology, New Delhi. We thank Dr. P. K. Ghosh, Director, for his encouragement of this work. We are grateful to Professor G. Mehta, Director, Indian Institute of Science, Bangalore, for a generous gift of Amberlyst-15 for this study. S.A.B. and C.G. thank CSIR, New Delhi, for a Fellowship.

References

- (a) Doyle, M. P.; McKervey, M. A.; Ye, T. *Modern Catalytic Methods for Organic Synthesis with Diazo Compounds. From Cyclopropanes to Ylides*; Wiley-Interscience: New York, 1998; (b) Padwa, A.; Weingarten, M. D. *Chem. Rev.* **1996**, *96*, 223–269; (c) Ye, T.; McKervey, M. A. *Chem. Rev.* **1994**, *94*, 1091–1160; (d) Padwa, A.; Hornbuckle, S. A. *Chem. Rev.* **1991**, *91*, 263–309; (e) Calter, M. A. *Curr. Org. Chem.* **1997**, *1*, 37–70; (f) Padwa, A. *Topp. Curr. Chem.* **1997**, *189*, 121–158.
- (a) Srikrishna, A.; Ramachary, D. B. *Tetrahedron Lett.* **1999**, *40*, 1605–1606; (b) Smith, III, A. B.; Toder, B. H.; Branca, S. J.; Dieter, R. K. *J. Am. Chem. Soc.* **1981**, *103*, 1996–2008; (c) Erman, W. F.; Stone, L. C. *J. Am. Chem. Soc.* **1971**, *93*, 2821–2823.
- Sengupta, S.; Mondal, S. *Tetrahedron Lett.* **1999**, *40*, 8685–8688.
- (a) Hecker, S. J.; Werner, K. M. *J. Org. Chem.* **1993**, *58*, 1762–1765; (b) Padwa, A.; Hornbuckle, S. F.; Zhang, Z.; Zhi, L. *J. Org. Chem.* **1990**, *55*, 5297–5299.
- Muthusamy, S.; Babu, S. A.; Gunanathan, C. *Synth. Commun.* **2001**, in press.
- Pansare, S. V.; Jain, R. P.; Bhattacharyya, A. *Tetrahedron Lett.* **1999**, *40*, 5255–5258.
- Doyle, M. P.; Trudell, M. L. *J. Org. Chem.* **1984**, *49*, 1196–1199.
- Regitz, M.; Mass, G. *Diazo Compounds-Properties and Synthesis*; Academic Press: New York, 1986; pp. 90–165.
- Amberlyst-15 is a macroreticular type sulfonic acid based polystyrene cation exchange resin and used in this study in the H⁺ form. Amberlyst is a trademark of the Rohm and Hass Co.
- Coppola, G. M. *Synthesis* **1984**, 1021–1023.
- Perni, R. B. *Synth. Commun.* **1989**, *19*, 2383–2387.
- Ballini, R.; Marziali, P.; Mozzicafreddo, A. *J. Org. Chem.* **1996**, *61*, 3209–3211.
- (a) Patwardhan, S. A.; Dev, S. *Synthesis* **1974**, *11*, 348–349; (b) Gupta, S. K. *J. Org. Chem.* **1976**, *41*, 2642–2646; (c) Dann, A. E.; Davis, J. B.; Nagler, J. J. *Chem. Soc., Perkin Trans. 1* **1979**, 158–160.
- Bongini, A.; Cardillo, G.; Orena, M.; Sandri, S. *Synthesis* **1979**, 618–620.
- All new compounds gave satisfactory spectral data consistent with their structures. Selected spectral data, (**2b**): colorless solid mp 103–105°C; IR (KBr) 3391, 2927, 2845, 1678, 1603, 1576, 1512, 1422, 1250, 1181, 1103, 1029, 977, 821 cm⁻¹; ¹H NMR (200 MHz, CDCl₃/CD₃CN) δ 7.89 (d, 2H, *J*=8.9 Hz, Arom.-H), 6.99 (d, 2H, *J*=8.9 Hz, Arom.-H), 4.78 (s, 2H, OCH₂), 3.86 (s, 3H, OCH₃), 3.49 (br s, 1H, OH); ¹³C NMR (50 MHz, CDCl₃/CD₃CN) δ 54.9 (OCH₃), 64.6 (OCH₂), 113.6 (=CH), 126.3 (quat.-C), 129.5 (=CH), 163.8 (quat.-C), 197.0 (C=O). Anal. calcd for C₉H₁₀O₃: C, 65.05; H, 6.07. Found: C, 65.13; H, 6.12. (**4b**): colorless thick liquid; IR (neat) 3445, 2960, 2877, 1731, 1452, 1406, 1274, 1158, 1069, 732 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 4.19 (s, 2H, OCH₂), 3.32 (br s, 1H, OH), 2.50 (t, 2H, *J*=7.0 Hz), 1.40–2.21 (m, 9H); ¹³C NMR (50 MHz, CDCl₃) δ 21.1 (CH₂), 23.9 (CH₂), 30.1 (CH₂), 36.4 (CH₂), 38.5 (CH₂), 48.4 (CH), 68.6 (OCH₂), 210.0 (C=O), 221.2 (C=O). Anal. calcd for C₉H₁₄O₃: C, 63.51; H, 8.29. Found: C, 63.59; H, 8.37. (**7c**): colorless solid mp 120–122°C; IR (KBr) 3380, 2944, 2911, 1760, 1457, 1413, 1232, 1097, 1076, 1020, 938 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 4.16 (dd, 2H, *J*₁=13.5 Hz, *J*₂=1.6

- Hz, OCH₂), 2.91 (s, 1H, OH), 1.90–2.00 (m, 1H), 1.35–1.75 (m, 7H), 1.22 (s, 3H, CH₃); ¹³C NMR (50 MHz, CDCl₃) δ 13.7 (CH₃), 21.0 (CH₂), 23.5 (CH₂), 33.1 (CH₂), 34.0 (CH₂), 51.3 (quat.-C), 67.9 (OCH₂), 106.0 (quat.-C), 217.6 (C=O); mass *m/z* (%): 170 (M⁺, 24), 153 (20), 142 (6), 124 (8), 112 (63), 97 (48), 83 (48), 69 (69), 55 (96), 41 (100). Anal. calcd for C₉H₁₄O₃: C, 63.51; H, 8.29. Found: C, 63.46; H, 8.28.
16. Miller, D. J.; Moody, C. J. *Tetrahedron* **1995**, *51*, 10811–10843.
17. Whitsell, J. K.; Buchanan, C. M. *J. Org. Chem.* **1986**, *51*, 5443–5445.
18. Muthusamy, S.; Babu, S. A.; Gunanathan, C.; Suresh, E.; Dastidar, P.; Jasra, R. V. *Tetrahedron* **2000**, *56*, 6307–6318.
19. White, J. D.; Bolton, G. L.; Dantanarayana, A. P.; Fox, C. M. J.; Hiner, R. N.; Jackson, R. W.; Sakuma, K.; Warrier, U. S. *J. Am. Chem. Soc.* **1995**, *117*, 1908–1939.