

Supplementary information

Sulfonated reduced graphene oxide catalyzed cyclization of hydrazides and carbon dioxide to 1,3,4-oxadiazoles under sonication

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Table S1. Cyclization of 4-methyl benzohydrazide under various conditions.

Temperature / Sonication	Time (h)	5 wt% catalyst loading		20 wt% catalyst loading		50 wt% catalyst loading	
		PhCONHNH ₂	POxdO	PhCONHNH ₂	POxdO	PhCONHNH ₂	POxdO
25 °C / Conventional	3	100	0	93.4	6.6	91.6	8.4
	6	100	0	87.2	12.8	85.5	14.5
	24	99.8	0	78.8	20.2	79.2	20.8
	48	99.0	1.0	76.6	23.4	75.0	25.0
	72	99.0	1.0	71.3	28.7	69.9	30.1
	96	98.1	1.8	63.7	36.3	61.7	38.3
	Time (min)	5 wt% catalyst loading		20 wt% catalyst loading		50 wt% catalyst loading	
		PhCONHNH ₂	POxdO	PhCONHNH ₂	POxdO	PhCONHNH ₂	POxdO
25 °C / Sonication	10	99.0	1.0	93.0	7.0	92.3	7.7
	30	94.5	5.5	83.6	16.4	81.2	18.8
	50	94.0	6.0	69.7	30.3	65.0	35.0
	60	93.0	7.0	66.0	34.0	63.6	36.4
	90	92.8	7.2	63.2	36.8	62.1	37.9
	120	92.8	7.1	61.0	39.0	60.0	40
40 °C / Sonication	10	98.0	2.0	89.9	10.1	88.2	11.8
	30	97.4	2.6	81.8	18.2	76.8	23.2
	50	92.6	7.4	67.5	32.5	63.0	37.0
	60	91.8	8.2	63.9	36.1	62.2	37.8
	90	91.0	8.2	63.0	37.0	61.0	39.0
	120	92.0	8.0	60.6	39.4	60.4	39.6
50 °C / Sonication	10	97.0	3.0	89.1	10.9	88.0	12.0
	30	93.0	7.0	74.5	25.5	73.0	27.0
	50	90.1	9.9	62.0	38.0	70.2	29.8
	60	90.0	9.0	59.7	40.3	68.1	41.9
	90	90.3	9.7	59.0	41.0	57.7	42.3
	120	90.7	9.3	58.9	41.1	57.2	42.8
75 °C / Sonication	10	97.1	1.9	91.2	9.8	89.5	10.5
	30	92.8	1.5	83.2	16.8	79.8	20.2
	50	93.6	6.4	70.0	30.0	70.0	30.0
	60	90.3	9.7	72.4	27.6	69.3	30.7
	90	90.6	9.4	73.6	26.4	70.0	30.0
	120	90.8	8.2	74.0	26.0	71.0	29.0
100 °C / Sonication	10	98.0	4.0	92.0	8.0	91.0	9.0
	30	96.2	4.0	87.0	13.0	85.0	15.0
	50	95.1	4.9	79.1	20.9	77.7	22.3
	60	95.0	5.0	79.6	20.4	78.1	21.9
	90	95.0	9.7	80.9	19.1	80.0	20.0
	120	96.0	9.3	81.3	18.7	80.2	19.8

^a All reactions employed in sealed, Teflon-lined 25 mL round bottomed flasks. Aliquots were picked out at time intervals listed in the table s1. The products were extracted in DMSO-d₆ (1 mL) and separated from the nano catalyst by the syringe filtration (0.2 μm PTFE). Conversions were checked by integration of the hydrazide peak (CONHNH) of 4-methyl benzohydrazide or the ortho cyclic 1,3,4-oxadiazole of CONH.



























