RSC Advances

ARTICLE

Highly reduced graphene oxide /ZrO_x– $MnCO_3$ or –Mn_2O_3 nanocomposite as an efficient catalysts for selective aerial oxidation of benzylic alcohols

Mohamed E. Assal,[a] Mohammed Rafi Shaik,[a] Mufsir Kuniyil,[a] Mujeeb Khan,[a] Abdulrahman Al–Warthan,[a] Mohammed Rafiq H. Siddiqui,[a] Sohail M. A. Khan,[b] Wolfgang Tremel,[c] Muhammad Nawaz Tahir*[c,d] and Syed Farooq Adil*[a]

[a]Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Kingdom of Saudi Arabia. E-mail: sfadil@ksu.edu.sa

[b]Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, Ontario M5B 2K3, Canada.

[c]Institute of Inorganic and Analytical Chemistry Johannes Gutenberg-University of Mainz, Germany. E-mail: tahir@uni-mainz.de

[d]Chemistry Department, King Fahd University of Petroleum and Materials, Dhahran 31261, Kingdom of Saudi Arabia

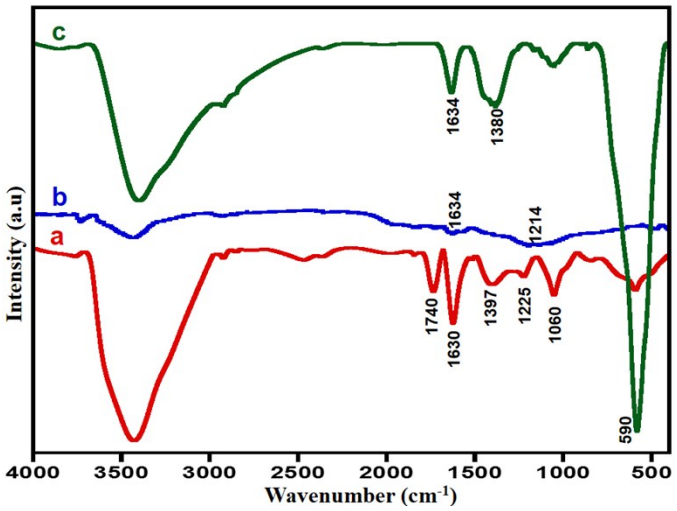

Fig. S1 FTIR spectra of (a) GO, (b) HRG, and (c) ZrO_x(1%)–$MnCO_3$/(1%)HRG.

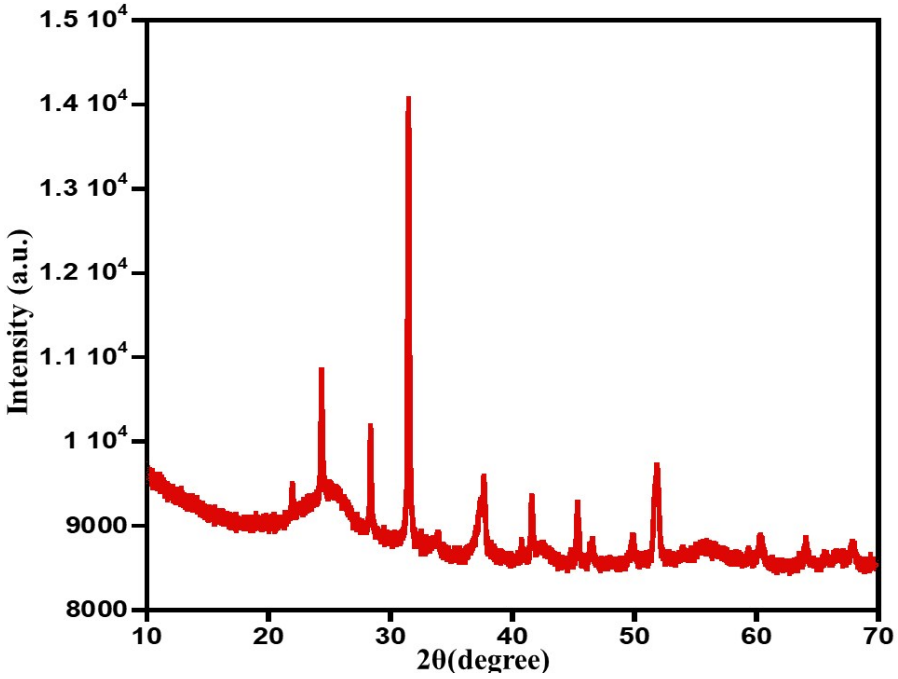

Fig. S2 XRD pattern of the ZrO_x(1%)–$MnCO_3$/(1%)HRG nanocomposite after using in the oxidation of benzyl alcohol reaction.

Table S1 Elemental composition of the catalyst ZrO_x(1%)–$MnCO_3$ and ZrO_x(1%)–$MnCO_3$/(1%)HRG.

Compound	Element Mass (%)			
	C	O	Mn	Zr
ZrO_x (1%)-$MnCO_3$	29.97	15.84	53.24	0.95
ZrO_x (1%)-$MnCO_3$/(1%)HRG	35.07	18.38	45.3	1.25

Table S2 Catalytic oxidation of benzyl alcohol by molecular oxygen.

Entry	Catalyst	Conv. (%)	Sp. activity (mmol.g^{-1}.h^{-1})	Sel. (%)
1	HRG	2.97	1.32	>99
2	ZrO_x(1%)–$MnCO_3$	74.18	32.97	>99
3	ZrO_x(1%)–$MnCO_3$/(1%)HRG	100.0	44.44	>99
4	ZrO_x(1%)–$MnCO_3$/(3%)HRG	93.29	41.46	>99
5	ZrO_x(1%)–$MnCO_3$/(5%)HRG	84.14	37.40	>99
6	ZrO_x(1%)–$MnCO_3$/(7%)HRG	67.27	29.89	>99

Reaction conditions: 2 mmol of benzyl alcohol, 300 mg of catalyst amount, calcination temperature at 300 °C, oxygen with rate 20 mL.min^{-1}, reaction temperature at 100 °C, 10 mL of toluene, and 9 min of reaction time.

Table S3 Influence of reaction temperature on the catalytic property.

Entry	Reaction Temp. (°C)	Conv. (%)	Sp. activity (mmol.g^{-1}.h^{-1})	Sel. (%)
1	20	38.4	17.06	>99
2	40	53.5	23.79	>99
3	60	68. 9	30.62	>99
4	80	84.7	37.65	>99
5	100	100.0	44.44	>99

Reaction conditions: 2 mmol of benzyl alcohol, 300 mg of catalyst amount, calcination temperature at 300 °C, oxygen with rate 20 mL.min^{-1}, 10 mL of toluene, and 9 min of reaction time.