Supplementary Materials for

Effect of mono-, di- and triethylene glycol on the activity of phosphate-doped NiMo/Al_2O_3 hydrotreating catalysts

Alexey L. Nuzhdin [1,*], Galina A. Bukhtiyarova [1,2], Aleksander A. Porsin [1], Igor P. Prosvirin [1], Irina V. Deliy [1,2], Vladimir A. Volodin [2,3], Evgeny Yu. Gerasimov [1,2], Evgeniya N. Vlasova [1,2] and Valerii I. Bukhtiyarov [1,2]

[1] Boreskov Institute of Catalysis SB RAS, 630090 Novosibirsk, Russia;

[2] Novosibirsk National Research University, 630090 Novosibirsk, Russia;

[3] Rzhanov Institute of Semiconductor Physics SB RAS, 630090 Novosibirsk, Russia.

E-mail address: anuzhdin@catalysis.ru

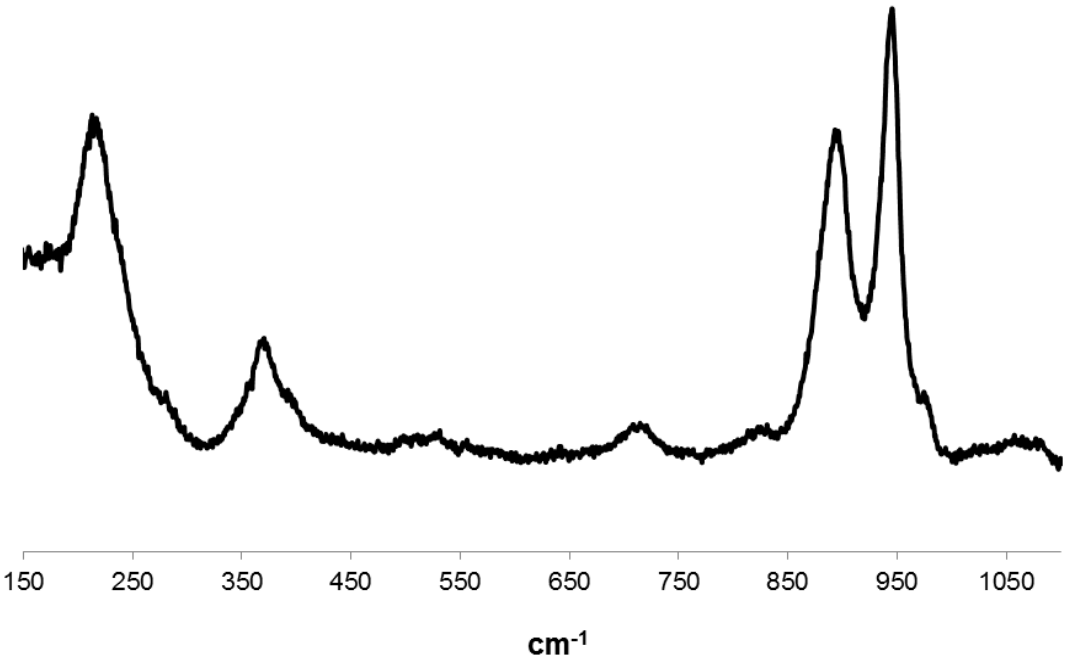

Figure S1. Raman spectrum of NiMoP-TEG solution.

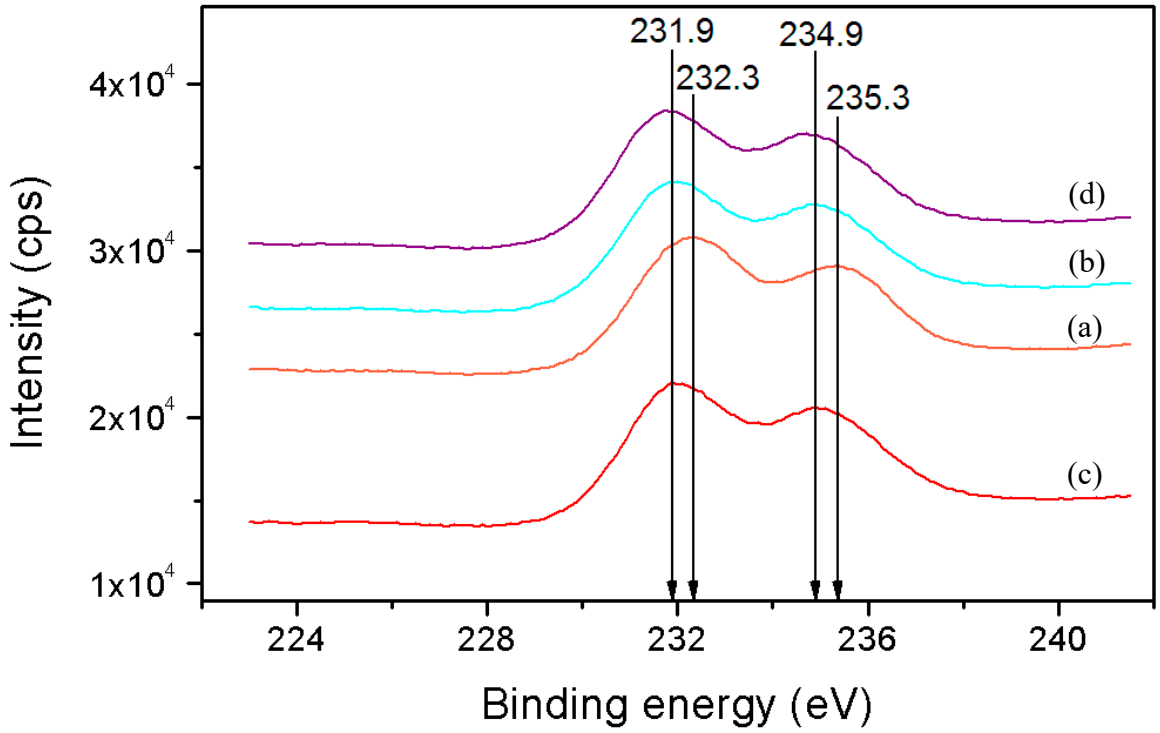

Figure S2. XPS Mo3d spectra of the catalysts in oxide form: (a) NiMoP/Al_2O_3, (b) NiMoP-EG/Al_2O_3, (c) NiMoP-DEG/Al_2O_3 and (d) NiMoP-TEG/Al_2O_3.

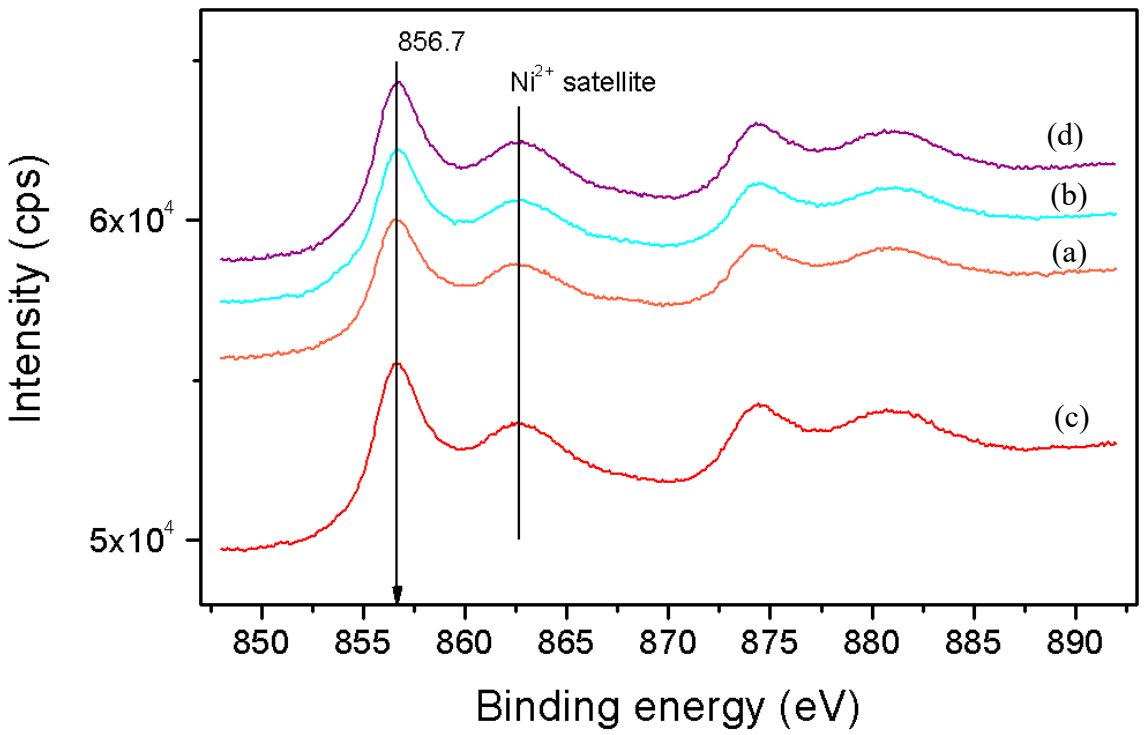

Figure S3. XPS Ni2p spectra of the catalysts in oxide form: (a) NiMoP/Al_2O_3, (b) NiMoP-EG/Al_2O_3, (c) NiMoP-DEG/Al_2O_3 and (d) NiMoP-TEG/Al_2O_3.

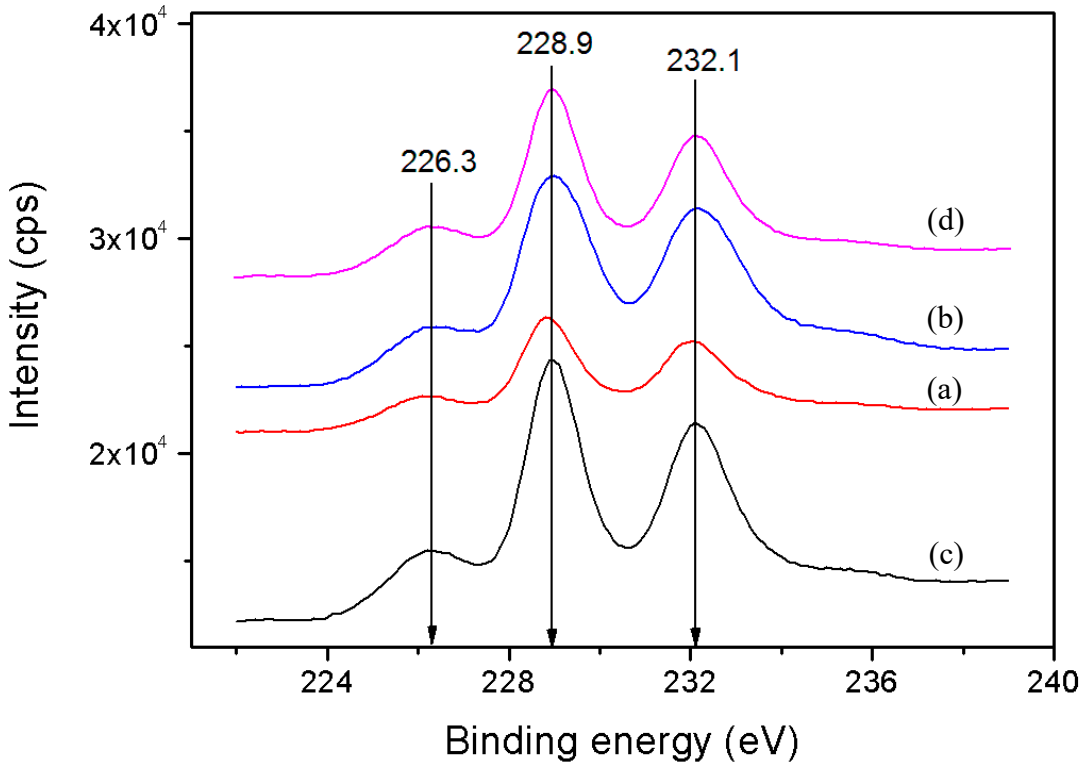

Figure S4. XPS Mo3d and S2s spectra of the catalysts in sulfide state: (a) NiMoP/Al_2O_3, (b) NiMoP-EG/Al_2O_3, (c) NiMoP-DEG/Al_2O_3 and (d) NiMoP-TEG/Al_2O_3.

Table S1. Molybdenum and nickel surface species of phosphate-doped NiMo/Al_2O_3 sulfide catalysts, as determined by XPS analysis.

Catalyst	Ni percentage, %			Mo percentage, %		
	NiS_x	NiMoS	Ni^{2+}	Mo^{4+}	Mo^{5+}	Mo^{6+}
NiMoP/Al_2O_3	8.8	56.3	34.8	75.8	14.9	9.3
NiMoP-EG/Al_2O_3	17.1	56.6	26.4	74.1	14.3	11.6
NiMoP-DEG/Al_2O_3	12.8	58.3	28.9	76.4	13.8	9.8
NiMoP-TEG/Al_2O_3	13.9	57.1	29.0	76.8	14.0	9.2

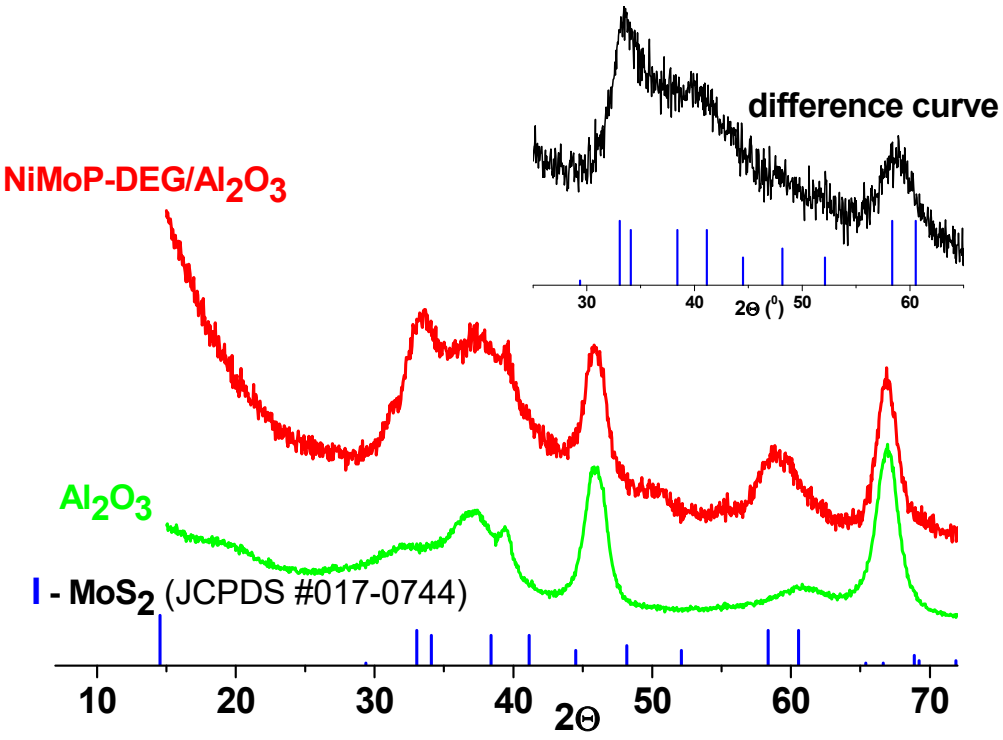

Figure S5. XRD patterns of the NiMoP-DEG/Al_2O_3 sulfide catalyst.

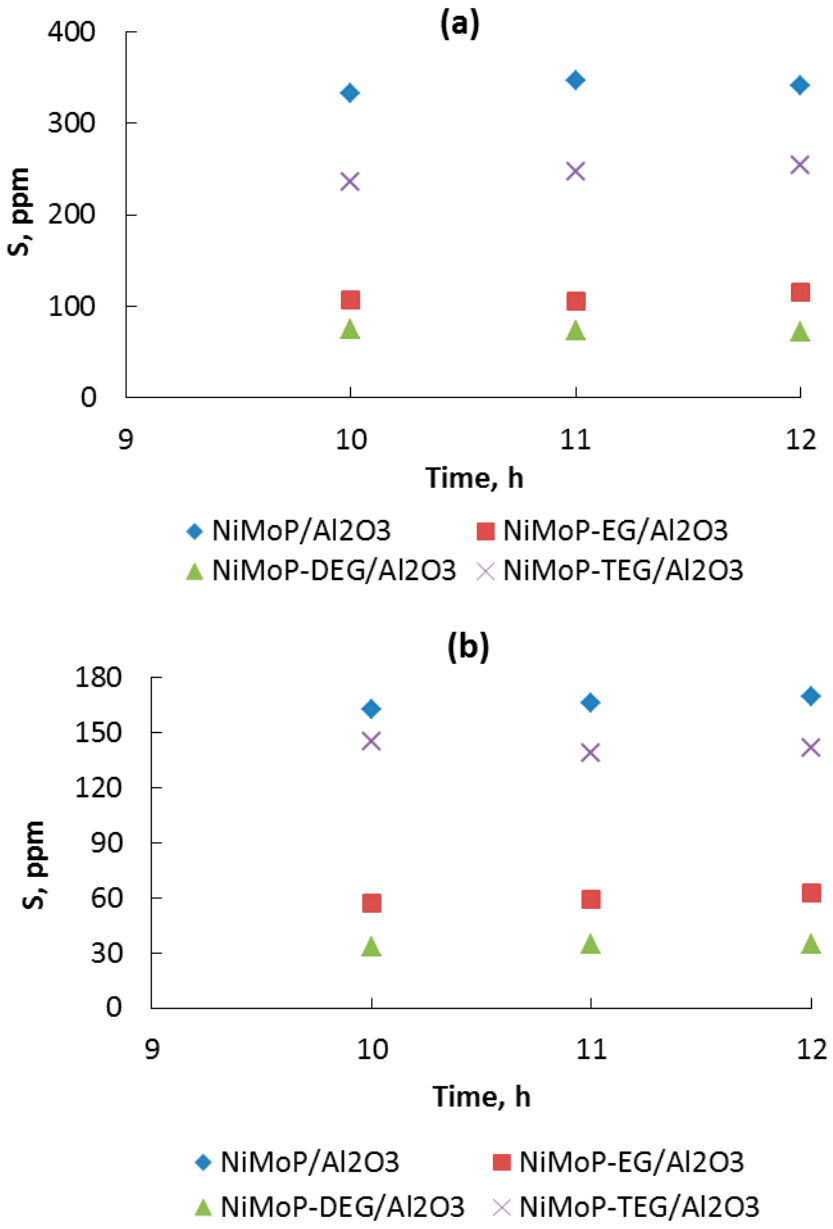

Figure S6. Catalytic properties of NiMo(P)/Al_2O_3 catalysts in hydrodesulfurization of SRGO: (a) 330 °C and (b) 340 °C.

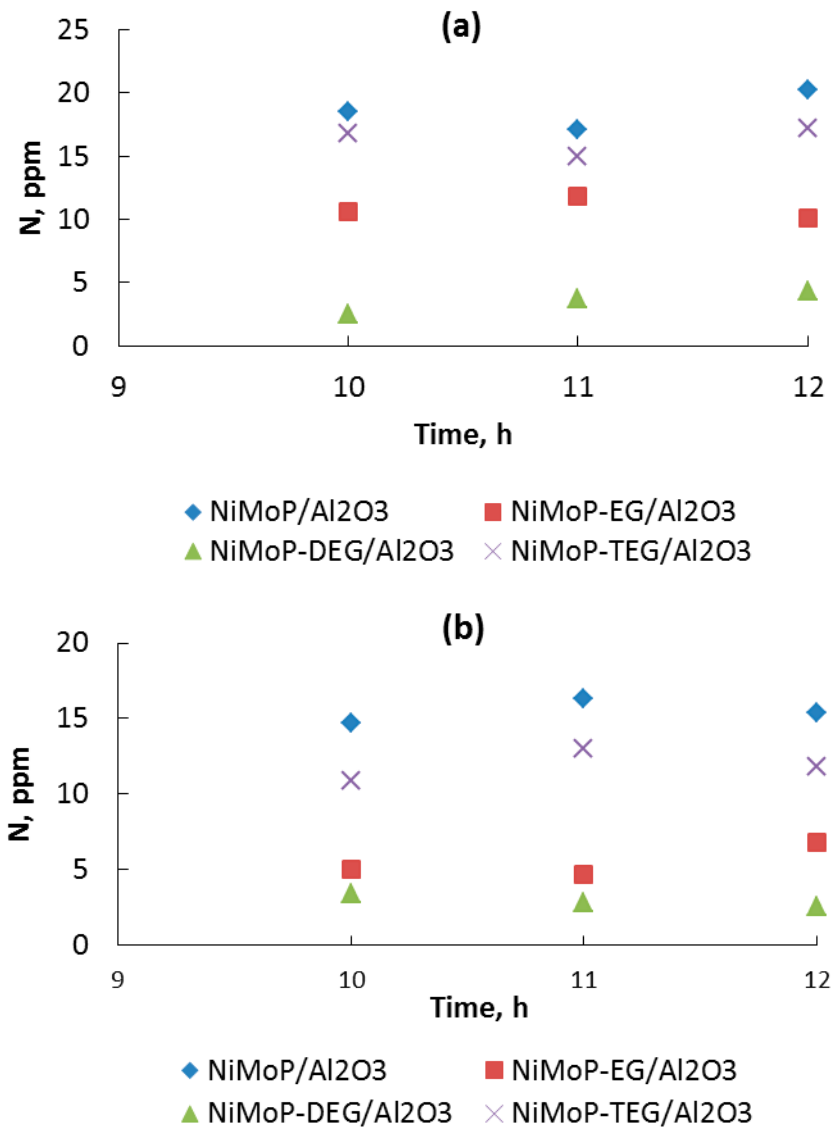

Figure S7. Catalytic properties of NiMo(P)/Al_2O_3 catalysts in hydrodenitrogenation of SRGO: (a) 330 °C and (b) 340 °C.

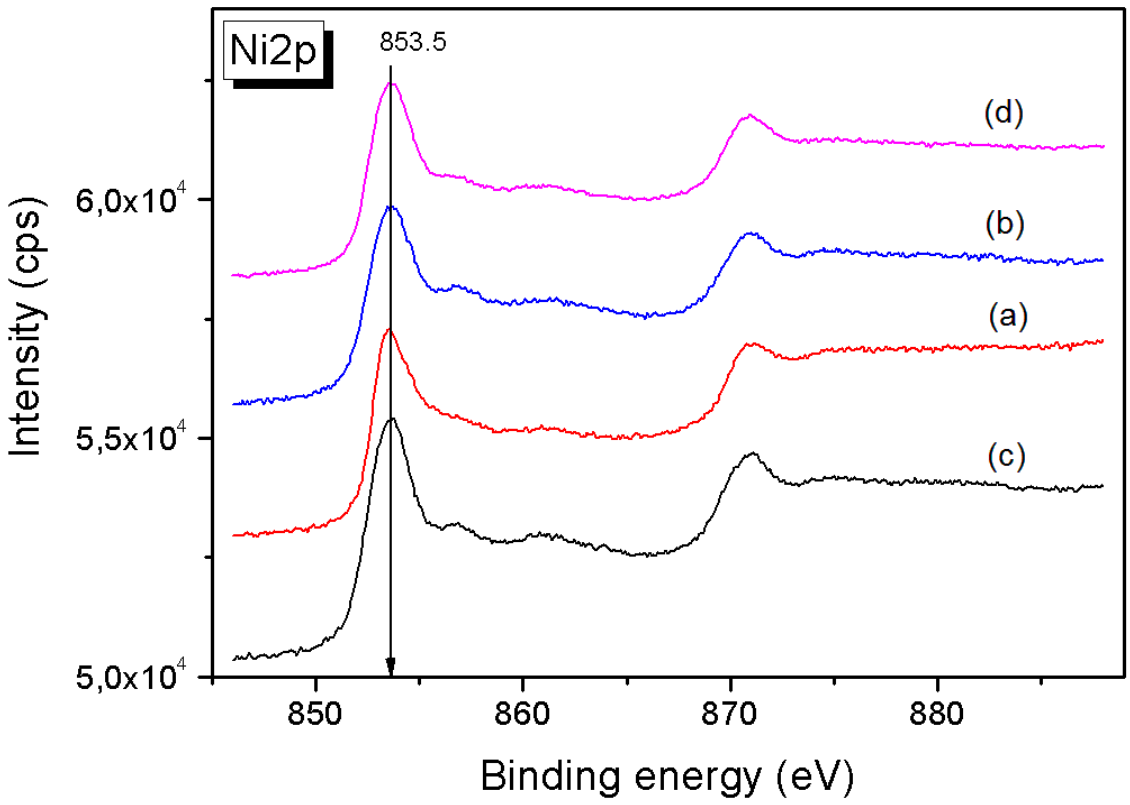

Figure S8. XPS Ni2p spectra of the catalysts in sulfide state: (a) NiMoP/Al_2O_3, (b) NiMoP-EG/Al_2O_3, (c) NiMoP-DEG/Al_2O_3 and (d) NiMoP-TEG/Al_2O_3.

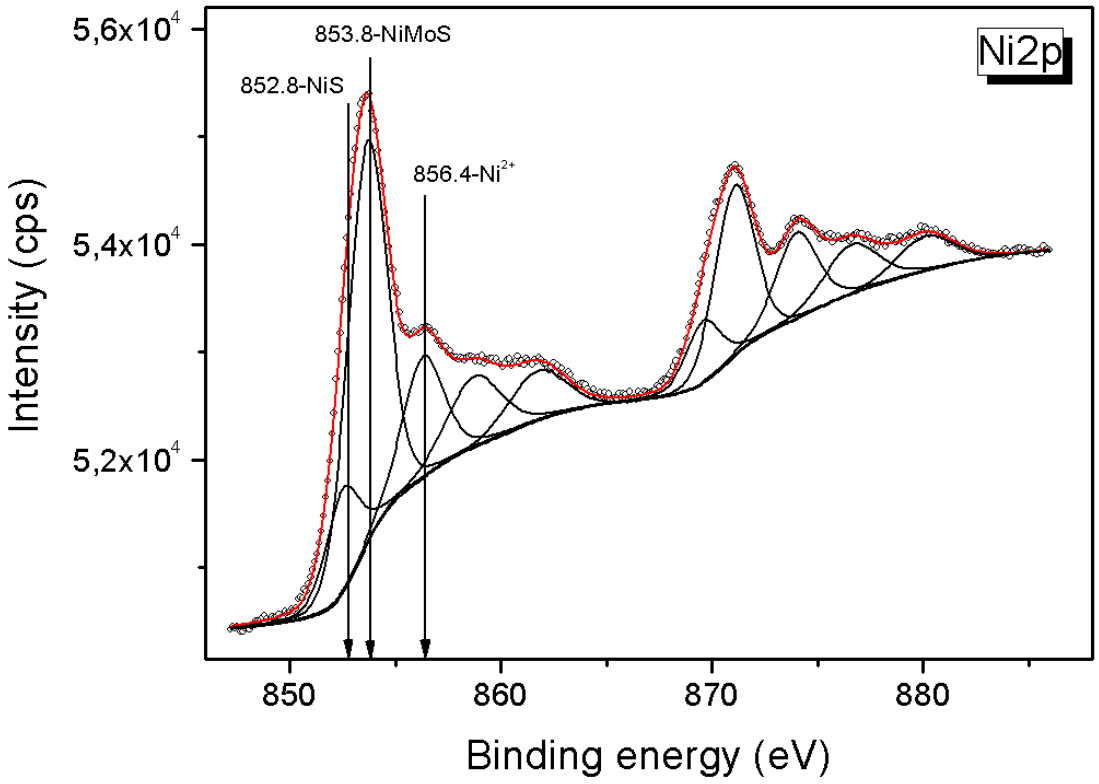

Figure S9. Deconvolution of XPS Ni2p spectrum of the NiMoP-DEG/Al_2O_3 sulfide catalyst.