

High Deoxygenation Ability of Rh Carbonyl Clusters toward
Oximes Leading to Nitrile Formation

Kiyotomi KANEDA,^{*} Kazuhiro DOKEN, and Toshinobu IMANAKA

Department of Chemical Engineering, Faculty of Engineering Science,
Osaka University, Toyonaka, Osaka 560

Nitriles are selectively prepared by the reaction of aldoximes with CO and H₂O in the presence of rhodium carbonyl clusters. Rh₁₂ and Rh₁₃ carbonyl cluster anions can be detected by IR spectroscopy.

Recently, we have found that the reduction of nitro compounds using CO and H₂O in the presence of rhodium catalysts showed the different reactivity between aromatic and aliphatic nitro compounds; nitrobenzene gave aniline, while nitropropane afforded propionitrile.^{1,2)} This difference may be due to the presence of α -hydrogen in the nitro compounds; nitropropane is reduced to nitrosopropane, which is easily converted into propionaldoxime as a tautomer. Therefore, we have thought that the formed oxime is a key intermediate for the nitrile formation. The reaction of propionaldoxime as a starting material was carried out under the conditions similar to those in the former nitropropane reduction²⁾ and expectedly, propionitrile was obtained in a high yield. Among many nitrile syntheses from oximes,³⁾ this rhodium-catalyzed reaction is unique because dehydration of oximes occurs in aqueous medium with formation of CO₂ and H₂.

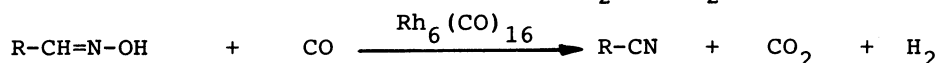
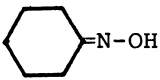
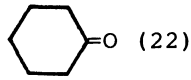
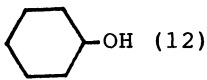
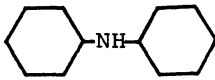


Table 1 shows the typical examples for the reaction of various oximes. The detectable products are nitriles, alcohols, and ketones. In the course of the reaction, H₂ and CO₂ were generated. Aldoximes except for benzaldoxime give the corresponding nitriles as main products. Ketoximes undergo hydrolysis to give ketones which further are reduced to alcohols. Rhodium compounds are characteristic of this nitrile formation as a catalyst; especially Rh carbonyl clusters

have the highest activity. Ru and Fe carbonyl clusters, e.g., $\text{Ru}_3(\text{CO})_{12}$ and $\text{Fe}(\text{CO})_5$ showed poor catalytic activity under the present reaction conditions. Interestingly, H_2O and basic additives, e.g., diamines and KOH are necessary for attaining high yields of nitriles. Without basic additives, the aldoxime was recovered quantitatively. The reaction solution showed dark green color, which on exposure to air changed to brown slowly. The IR spectrum of the condensed reaction mixture revealed the formation of $[\text{Rh}_{12}(\text{CO})_{30}]^{2-}$ and $[\text{Rh}_{13}(\text{CO})_{24}\text{H}_2]^{3-}$. 4,5)

The reaction of O-alkyl aldoximes did not give the corresponding nitriles. Here, we propose a possible scheme for the nitrile formation which involves nucleophilic attack of $\text{C}=\text{N}-\text{O}^-$ species to the coordinated CO moiety. Specificity of the rhodium catalyst for the present nitrile formation seems to be ascribed to high deoxygenation ability of coordinated carbonyl moiety to rhodium clusters. Oximes are one of the important intermediates in this nitrile formation from nitro compounds.

Table 1. Reaction of Various Oximes with CO and H_2O Using $\text{Rh}_6(\text{CO})_{16}$ Catalyst^{a)}

Oxime	Products (% , based on oximes used)		
$\text{C}_2\text{H}_5-\text{CH}=\text{N}-\text{OH}$	$\text{C}_2\text{H}_5-\text{CN}$ (73)	Propanol (12)	
$\text{C}_4\text{H}_7-\text{CH}=\text{N}-\text{OH}$	$\text{C}_4\text{H}_9-\text{CN}$ (71)	Pentanol (17)	
cyclo- $\text{C}_6\text{H}_{11}-\text{CH}=\text{N}-\text{OH}$	c- $\text{C}_6\text{H}_{11}-\text{CN}$ (77)	c- $\text{C}_6\text{H}_{11}-\text{CH}_2\text{OH}$ (12)	
$\text{Ph}-(\text{CH}_2)_2-\text{CH}=\text{N}-\text{OH}$	$\text{Ph}-(\text{CH}_2)_2-\text{CN}$ (76)	$\text{Ph}-(\text{CH}_2)_3\text{OH}$ (5)	
$\text{Ph}-\text{CH}=\text{N}-\text{OH}$	$\text{Ph}-\text{CN}$ (22)	$\text{Ph}-\text{CH}_2\text{OH}$ (46)	
	 (22)	 (12)	 (28)

a) Oxime 5 mmol, $\text{Rh}_6(\text{CO})_{16}$ 0.05 mmol, H_2O 2.8 ml, tetramethyl-1,3-propanediamine 5 mmol, ethoxyethanol 2 ml, P_{CO} 8 atm, 40 °C, 5 h.

References

- 1) K. Kaneda, M. Hiraki, T. Imanaka, and S. Teranishi, *J. Mol. Catal.*, **12**, 385 (1981).
- 2) K. Kaneda, T. Mori, M. Kobayashi, T. Imanaka, and S. Teranishi, *Chem. Lett.*, **1985**, 1339.
- 3) For transition metal-catalyzed reaction, see: O. Attanasi, P. Palma, and F. Serra-Zanetti, *Synthesis*, **1983**, 741.
- 4) P. Chini and S. Martinengo, *Inorg. Chim. Acta*, **3**, 299 (1969).
- 5) V. G. Albano, A. Ceriotti, P. Chini, G. Ciani, S. Martinengo, and W. N. Anker, *J. Chem. Soc., Chem. Commun.*, **1975**, 859.

(Received November 13, 1987)