CHEMISTRY LETTERS, pp. 1609-1612, 1985.

ENANTIOFACE-DIFFERENTIATING HYDROGENATION OF 2-ALKANONES OVER MODIFIED RANEY NICKEL

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2-Octanone was hydrogenated over tartaric acid-NaBr-modified Raney nickel in the presence of pivalic acid at various temperatures. The hydrogenation at 50-60 °C gave the best result with regard to the optical yield. Almost 80% of the optical yields were attained in the hydrogenations of various 2-alkanones.

The enantioface-differentiating hydrogenation of alkanones has been widely studied, using optically active reagents or catalysts. Recently high optical yields were first reported by Midland et al.[1)] 2-Alkanones were hydrogenated in the optical yields more than 70% with asymmetrically modified boranes. No excellent catalysts for the enantioface-differentiating hydrogenation of alkanones have been developed. Reactions with asymmetrically modified catalysts possess an advantage over those with optically active reagents. The advantage is that a large amount of optically active compounds can be obtained from a small amount of optically active compounds for the catalyst preparation.

It was well documented that tartaric acid-sodium bromide-modified Raney nickel(TA-NaBr-MRNi) was an excellent catalyst for the enantioface-differentiating hydrogenation of β-ketoesters.[2)] More than 80% of the optical yields were attained in the hydrogenation of various kinds of β-ketoesters. However, 2-alkanones were hydrogenated only in poor optical yields over TA-NaBr-MRNi under the conditions suitable for β-ketoesters. In a previous paper we reported that the optical yields of the hydrogenation of 2-alkanones over TA-NaBr-MRNi were remarkably improved by the addition of pivalic acid to the reaction system, when the hydrogenation was

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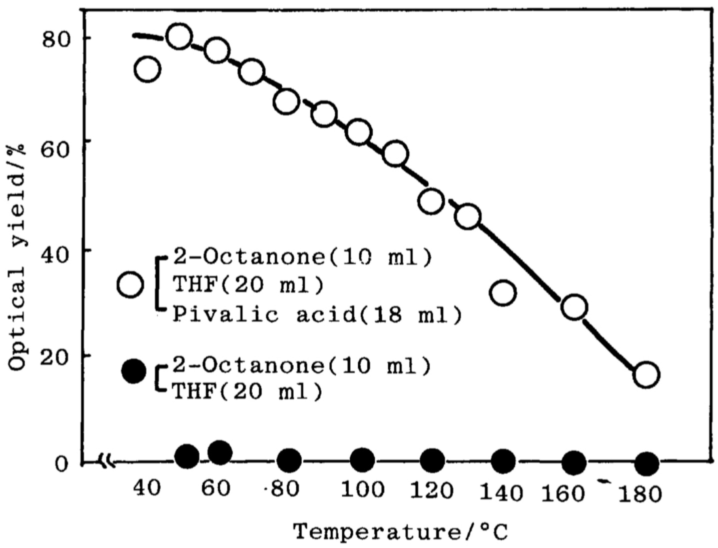

Catalyst: TA-NaBr-MRNi prepared from 3.8 g of the alloy (Ni/Al=42/58). Initial hydrogen pressure: 90 kg/cm^2.

Fig. 1. Effects of added pivalic acid on optical yield.

performed at 100 °C.$^{3)}$ The optical yields around 65% were attained in the hydrogenation of 2-alkanones. It was required to improve further the optical yields for obtaining optically pure alcohols from the hydrogenation products.

In the course of studies to improve the optical yield, the effect of the added pivalic acid on the optical yield was examined at various temperatures, using 2-octanone as the substrate. The results are shown in Fig 1. The optical yield varied with both the addition of pivalic acid to the reaction system and the change in the hydrogenation temperature. In the absence of pivalic acid the optical yields were negligible in the range of hydrogenation temperature examined, while in the presence of pivalic acid 2-octanone was hydrogenated in a fairly good optical yield. The optical yield in the presence of pivalic acid was improved when the temperature was lowered. The optical yield around 80% was attained at 50-60 °C. The sensitivity of the optical yield to the hydrogenation conditions suggests that the interaction between 2-octanone and tartaric acid is rather weak and the interaction mode is changeable.

A typical procedure for the enantioface-differentiating hydrogenation of 2-octanone is as follows The Raney nickel alloy(Ni/Al=42/58, 3.8 g) was added by portions to 40 ml of a 20% aqueous solution of NaOH. Then the mixture was allowed to stand at 100 °C for 1 h. After the removal of the alkaline solution, the catalyst was washed 30 times with 30 ml portions of deionized water. The resulting catalyst was modified at 100 °C for 1 h with an aqueous solution(200 ml) containing tartaric acid(2 g) and NaBr(12 g), adjusted to pH 3.2 with NaOH. After the removal of modifying solution, the catalyst was washed successively with a 20 ml portion of water , two 100 ml portions of methanol, and two 30 ml portions of anhydrous tetrahydrofuran(THF). TA-NaBr-MRNi thus obtained was employed for the hydrogenation of 2-octanone(10 ml) in the mixture of pivalic acid(18 ml) and THF(20 ml) under an initial hydrogen pressure of 90 kg/cm^2. The reaction was carried out at 60 °C to be completed in 4 d. After the completion of the reaction the catalyst was removed by decantation and the solvent was evaporated. The product was washed with a saturated aqueous solution of K_2CO_3 to remove pivalic acid. A simple distillation gave 7.5 g of 2-octanol(chemical yield, 90%). The optical yield was 80%($[\alpha]_D^{20}$+7.8(neat)).

Optically pure 2-octanol was prepared from the partially optically active one. 2-Octanol(10 g ; optical purity, 77%) was treated with phthalic anhydride in the presence of pyridine.4) The hydrogen phthalate of 2-octanol thus obtained(21 g; $[\alpha]_D^{20}$+34(c 6, EtOH)) was recrystallized from acetonitrile to afford the optically pure ester(10 g; $[\alpha]_D^{20}$+47(c 6, EtOH), lit,5) $[\alpha]_D$ +48.4(EtOH)). Optically pure 2-octanol(3.7 g; $[\alpha]_D^{20}$+9.8(neat)) was obtained by the hydrolysis of the optically

Table 1. Hydrogenation of 2-Alkanones(R-CO-CH_3) over (R,R)-TA-NaBr-MRNi a)

Substrate/R-	$[\alpha]_D^{20}$/° of Product	Optical yield/% b)	Configuration of product
CH_3CH_2-	+8.8	63	S
$CH_3(CH_2)_3$-	+9.3	80	S
$CH_3(CH_2)_4$-	+7.4	71	S
$CH_3(CH_2)_5$-	+7.8	80	S
$CH_3(CH_2)_7$-	+6.6	76	S
$CH_3(CH_2)_{10}$-	+5.4	75	S

a) Hydrogenation conditions.
Catalyst: RNi(prepared from 3.8 g of the alloy(Ni/Al=42/58)) modified with 200 ml of aq. solution containing (R,R)-TA(2 g) and NaBr(12 g) at pH 3.2, 100 °C for 1 h.
Substrate: 10 ml of 2-alkanone in 18 ml of pivalic acid and 20 ml of THF.
Hydrogenation temperature: 60 °C. Initial hydrogen pressure: 90 kg/cm^2.

b) The optical yields of the hydrogenation of 2-alkanones were estimated from the specific rotations of the pure enantiomers: (S)-2-butanol, $[\alpha]_D^{20}$+13.87(neat);6) (S)-2-hexanol, $[\alpha]_D^{20}$ +11.57(neat);6) (S)-2-heptanol, $[\alpha]_D^{20}$+10.32(neat);6) (S)-2-octanol, $[\alpha]_D^{20}$ +9.76(neat);6) (S)-2-decanol, $[\alpha]_D^{20}$+8.68(neat);6) (S)-2-tridecanol, $[\alpha]_D^{20}$ +7.22(neat).6) pure hydrogen phthalate.$^{5)}$

Various kinds of 2-alkanones were hydrogenated at 60 °C over TA-NaBr-MRNi. The results are listed in Table 1. All the hydrogenations of 2-alkanones examined gave (S)-alcohols in excess when (R,R)-TA-NaBr-MRNi was employed as the catalyst. 2-Alkanones except 2-butanone were hydrogenated in the optical yields of 70-80%. 2-Butanone was hydrogenated in the optical yield of 63%. It is noteworthy that TA-NaBr-MRNi can efficiently differentiate the two alkyl groups adjacent to the carbonyl group, even when the two alkyl groups are methyl and ethyl ones.

The results obtained by the present work demonstrate the possibility that the combination of the enantioface-differentiating hydrogenation of 2-alkanones and the preferential crystallizations of derivatives of the hydrogenation products would present a general procedure for the preparation of optically pure 2-alkanols. The work along this line is under way.

The author thanks Prof. Yoshiharu Izumi of Osakagakuin University, and Dr. Tadao Harada and Dr. Hiroshi Ozaki of Osaka University for their many helpful discussions and suggestions in the course of this work.

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(Received July 5, 1985)