# $C_2$ Diamine, Pseudo-$C_2$ Poly(amide) and Poly(urea) as Chiral Inductors in Asymmetric Catalysis

**Patrick Gamez, Branko Dunjic, Fabienne Fache and Marc Lemaire***

*Institut de Recherches sur la Catalyse, Laboratoire de Catalyse et Synthèse Organique et Université C. Bernard, ESCIL, Bât. 308, 43 Bd du 11 novembre 1918, 69622 Villeurbanne Cedex, France*

Chiral $C_2$ diamine, poly(amide) and poly(urea) act as inductors both in asymmetric hydride transfer reduction of acetophenone and carbon–carbon bond formation with high enantioselectivity of up to 95% enantiomeric excess.

Asymmetric catalysis is an important subject in organic chemistry; the development of heterogeneous asymmetric catalysis systems is challenging both theoretically and practically. Chiral polymers[1] have been used as part of the catalytic system in reactions as different as Michael additions,[2] carbonylation of allylic alcohols,[3] hydrogenation,[4] oxidation[5] and reduction.[6]

Recently, we reported the asymmetric homogeneous hydride transfer reduction of prochiral ketones using $C_2$ symmetric diamine ligands.[7] We report here the heterogenization of our system by incorporation of diamine **1** into polymer backbones leading to pseudo-$C_2$ symmetric polymer ligands and their use both in asymmetric hydride transfer reduction of carbonyls and in enantioselective carbon–carbon bond formation.

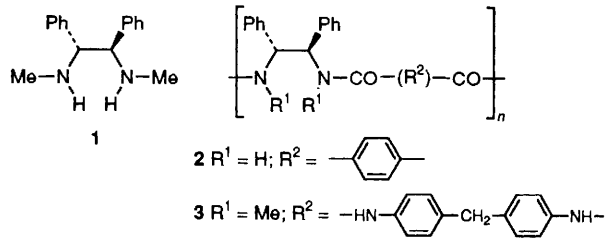


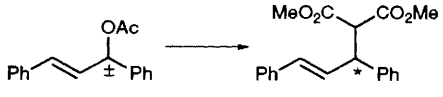

**Fig. 1** Chiral diamine, poly(amide) and poly(urea) ligands


**Scheme 1** Asymmetric C=O bond reduction. *Conditions*: KOH, ([KOH]/[Rh] = 6), 70 °C, PrⁱOH, $[Rh(C_6H_{10})Cl]_2$ (0.05 equiv.), L* or $L^*_n$ (0.1 equiv). $C_6H_{10}$ = hexa-1,5-diene.

**Table 1** Reduction of acetophenone by hydride transfer[a]

| Entry | Ligand (configuration) | Conversion (%) | *t*/day | E.e. (%) (configuration) |
|---|---|---|---|---|
| 1 | **1** (*S,S*) | 100 | 3.5 | 55 (*R*) |
| 2 | **2** (*S,S*) | 22 | 7 | 28 (*R*) |
| 3 | **3** (*R,R*) | 100 | 1 | 60 (*S*) |
| 4 | **3**[b] (*R,R*) | 100 | 1 | 59 (*S*) |
| 5 | **3**[c] (*R,R*) | 100 | 1 | 60 (*S*) |

[a] Acetophenone reduction. General procedure: A solution of the polymer (corresponding to 0.127 mmol of diamine), $[Rh(C_6H_{10})Cl]_2$ (0.0127 mmol) and KOH (0.0762 mmol) in propan-2-ol (4 ml) was stirred overnight at room temperature. Acetophenone (0.254 mmol) was then added and the mixture heated at 70 °C and monitored by capillary gas chromatography (GC) on a chiral column Cydex B which allows enantiomeric excess (e.c.) measurement. [b] First re-use. [c] Second re-use.




**Scheme 2** Asymmetric C–C bond formation. *Conditions*: $NaCH(CO_2Me)_2$, Pd–$L^*_n$ (0.05 equiv.), THF, room temp.

Diamine **1** was synthesized by an existing method.[8] Both poly(amide) **2** and poly(urea) **3** (Scheme 1) were synthesized by polycondensation with terephthaloyl chloride in *N,N*-dimethylacetamide and bis-(*p*-isocyanatophenyl)methane in dichloromethane respectively, at room temperature,[9] with a 1 : 1 ratio of diacid chloride to diamine for **2** and a 1.2 : 1 ratio of isocyanate to diamine for **3**. The polymer **2** is completely insoluble in all organic solvents and shows a noticeable crystallinity in X-ray analysis. In contrast, the polymer **3** is amorphous and soluble in THF ($[\alpha]_D^{20}$ −314.5; *c* 3.8, THF).

In acetophenone reduction (Scheme 1; Table 1, entries 1 and 3), the poly(urea) **3** leads to an increase in the reaction rate with an enantioselectivity slightly higher than that observed in the homogeneous reaction using diamine **1** at the same temperature. In addition, the complex [Rh–**3**] was reused twice after filtration and washing with propan-2-ol with no loss of activity and selectivity (Table 1, entries 3–5).

In contrast, poly(amide) **2** gave better result than poly(urea) **3** in carbon–carbon bond formation by Pd-catalysed enantioselective allylic substitution (Scheme 2; Table 2, entries 2 and 3). Here the enantiomeric excess obtained in the heterogeneous reaction is significantly lower (80%) than that for the diamine ligand **1** under homogeneous conditions (95%) which is close to the best results obtained by Pfaltz *et al.*[10] with oxazoline ligands. The catalyst may be separated during the work-up by a simple filtration.

$C_2$ diamines have already been shown to be good ligands for homogeneous hydride transfer reduction[7] and carbon–carbon bond formation.[10] Amides were also proved to be efficient in C=C reduction.[11] The possibility of using the corresponding poly(amides) as ligands for asymmetric C=O reduction with comparable selectivities has many advantages (separation and recycling). We assume that the key explanation for the enantioselectivity resides in the pseudo-$C_2$ symmetry of the polymer. To our knowledge, use of ureas as chiral ligand for asymmetric catalysis has not been described so far and poly(ureas) which are simply obtained are of special interest.

**Table 2** Pd-catalysed allylic substitution[a]

| Entry | Ligand (configuration) | Conversion (%) | *t*/day | E.e. (%) (configuration) |
|---|---|---|---|---|
| 1 | **1** (*S,S*) | 83 | 2 | 95 (*S*) |
| 2 | **2** (*S,S*) | 38 | 2 | 80 (*R*) |
| 3 | **3** (*R,R*) | 72 | 2 | 38 (*R*) |

[a] Catalytic allylic alkylation. General procedure: A solution of $NaCH(CO_2Me)_2$ (1.48 mmol), generated from 1.48 mmol of dimethyl malonate and 1.48 mmol of NaH (95%), in THF (10 ml), was added dropwise, under argon, to a THF mixture (10 ml) containing bisdibenzylideneacetonatopalladium (0.0624 mmol), polymer (corresponding to 0.624 mmol of diamine) and 1,3-diphenylprop-2-enyl acetate (1.25 mmol). The mixture was stirred at room temperature for 2 days and monitored by GC. E.e.s were determined by HPLC on a chiral column Astec cyclobound 1 and by polarimetry on a Perkin-Elmer 241 polarimeter.

This material allows us to obtain one of the first examples of enantioselective heterogeneous C–C bond formation, with easy recovery and the possibility of structural variation.

*Received, 17th March 1994; Com. 4/01615G*

## References


1 M. Aglietto, E. Chielleni, S. D'Antone, G. Ruggeri and R. Solaro, *Pure Appl. Chem.*, 1988, **60**, 415.
2 S. Inoue and Y. Kawano, *Makromol. Chem.*, 1978, **180**, 480.
3 H. Alper and N. Hamel, *J. Chem. Soc., Chem. Commun.*, 1990, 135.
4 R. L. Beamer, R. H. Belding and C. S. Fickling, *J. Pharm. Sci.*, 1969, 1419.
5 T. Sugimoto, Y. Matsumura, S. Tanimoto and M. Okano, *J. Chem. Soc., Chem. Commun.*, 1978, 926; S. Julià, J. Masana and J. C. Vega, *Angew. Chem., Int. Ed. Engl.*, 1980, **19**, 929; G. Parinello, R. Deschenaux and J. K. Stille, *J. Org. Chem.*, 1986, **51**, 4189; B. M. Kim and K. B. Sharpless, *Tetrahedron Lett.*, 1990, **31**, 3003.
6 N. Baba, Y. Matsumura and T. Sugimoto, *Tetrahedron Lett.*, 1978, **44**, 4281.
7 P. Gamez, F. Fache, P. Mangeney and M. Lemaire, *Tetrahedron Lett.*, 1993, 6897.
8 P. Mangeney, T. Tejero, A. Alexakis, F. Grosjean and J. F. Normant, *Synthesis*, 1988, 255.
9 J. Preston, *Encyclopedia of Polymer Science and Engineering*, vol. 11, Wiley–Interscience, New York, 1988, p. 320.
10 D. Müller, G. Umbricht, B. Weber and A. Pfaltz, *Helv. Chim. Acta*, 1991, **74**, 232.
11 A. Corma, M. Iglesias, C. del Pino and F. Sanchez, *J. Chem. Soc., Chem. Commun.*, 1991, 1253.