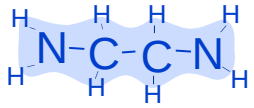
The power of polydentate ligands

This page illustrates some complexes of Ni^{2+} as a vehicle to consider the stability of complexes made by different kinds of ligands. The complexes shown all have N as the ligand atom for Ni^{2+}, which would be likely in view of the character of Ni^{2+} as an intermediate cation. The point, however, is that polydentate ligands (ligands with more than one ligand atom), and especially cyclic polydentate ligands, are more stable than monodentate ligands.

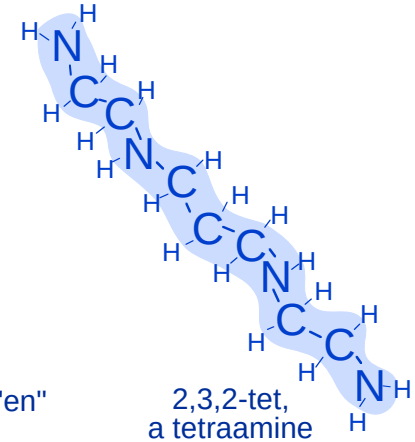
Ion: Ni^{2+}

Ligands:

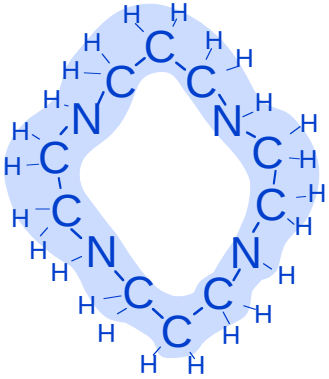
Ammonia



Ethylenediamine or "en"

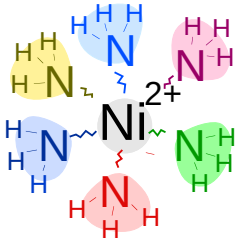


2,3,2-tet,
a tetraamine

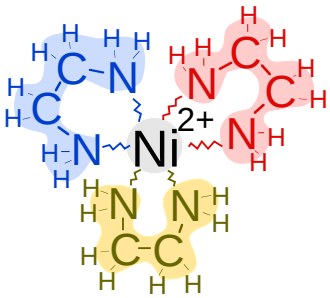


1,4,8,11-tetraazacyclotetradecane
or "cyclam"

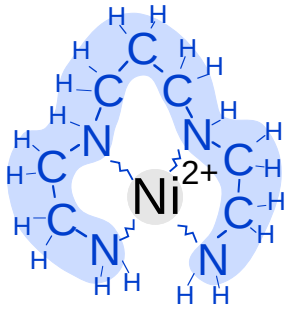
Complexes:



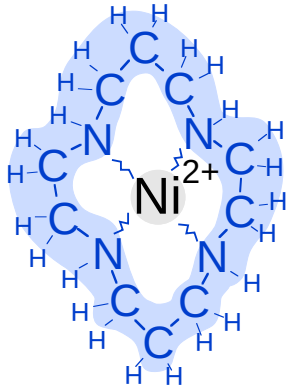
Complex with six monodentate ligands



Complex with three bent bidentate ligands



Complex with one bent tetradentate ligand



Complex with one undeformed cyclic tetradentate ligand

Stability:

Both of these complexes involve six N ligand atoms, but the complex on the right involves bidentate ligands. Of these two complexes, the complex with the polydentate ligand is far more stable:

$Ni^{2+}_{(aq)} + 6NH_3 \rightarrow Ni(NH_3)_6^{2+}$ Log K = 8.6

$Ni^{2+}_{(aq)} + 3en \rightarrow Ni(en)_3^{2+}$ Log K = 18.3

Both of these complexes involve one ligand with four N ligand atoms. Of these two complexes, the complex with the cyclic ligand is far more stable, with a stability constant about 10^6 times that of the linear ligand. This far greater stability is typical of cyclic ligands.

Virtually all of the information on this page is from W. Shytok, 1984, Metal-organic species in natural waters, in M.E. Fleet, ed., Mineralogical Association of Canada *Short Course in Environmental Chemistry,* p. 45-65. Shytok cites Cotton and Wilkinson (1980) and Wilkins et al. (1969) for the information about stability constants.