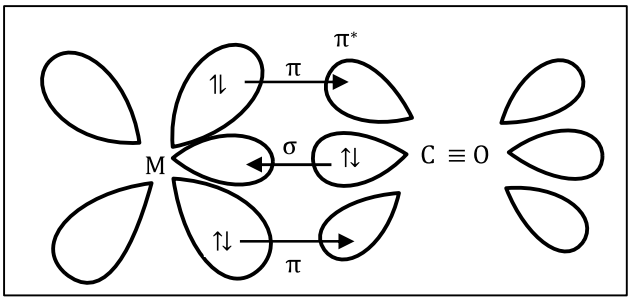
BONDING IN METAL CARBONYLS

Metal carbonyls represent a class of coordination complexes formed by transition metals coordinated with carbon monoxide ligands. The first metal carbonyl compound, $Ni(CO)_4$, was synthesized by Ludwig Mond in 1884. Carbon monoxide (CO) serves as a unique ligand in these complexes. It interacts with dπ orbitals of the metal center by accepting electrons into its antibonding π∗ orbital, thereby behaving as an acidic ligand. Compared to other ligands like H_2O or alkoxides (RO^-), CO exhibits weaker binding affinity.

The bonding of carbon monoxide ligands with transition metals involves the presence of lone pairs of electrons on both carbon and oxygen atoms. Carbonyl compounds are formed when carbon atoms donate electrons to the transition metals. In metal carbonyls, the M-C bond possesses both s and p character. CO, acting as a ligand, binds to the metal atoms through the M-C bond, although it is considered a poor donor.

To form the M-C σ bond, a lone pair of electrons from the carbonyl carbon is donated into a vacant orbital of the metal. On the other hand, to form the M-C π bond, a filled d orbital of the metal donates electrons to the vacant antibonding π∗ orbital of carbon monoxide. This reciprocal interaction, known as synergic bonding or back bonding, contributes to stabilizing the metal-ligand interaction.



Sigma bonds between metals and carbon are established through the donation of electrons from carbonyl molecules to the unoccupied orbitals within the metal atoms. In the realm of carbonyl ligands, the formation of a metal-carbon π bond ensues when two electrons are transferred from a filled d orbital of the metal to the unoccupied antibonding π* orbital of the carbonyl group. This interaction is commonly termed as back bonding of the carbonyl group. Through this mechanism, the sigma bond reinforces the π bond, thereby augmenting the strength of both the sigma and π bonds, reciprocally enhancing each other.