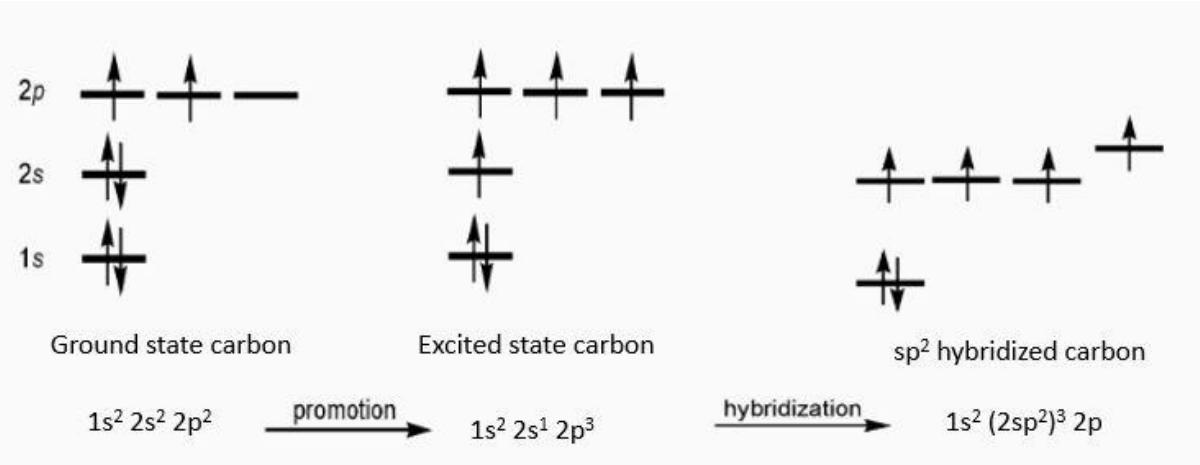
Hybridization of Carbon

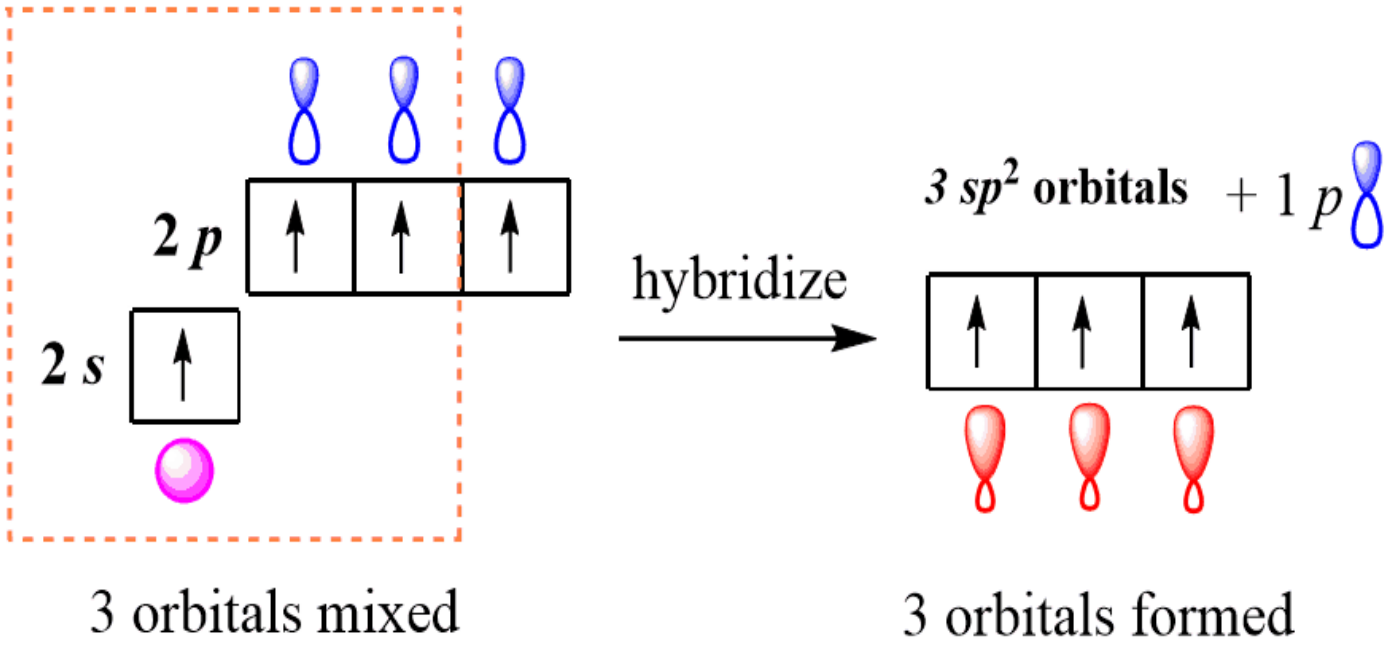
sp^2 Hybridization

2. Ethene, C_2H_4

Carbon in ethene forms three sigma bonds and one pi bond.

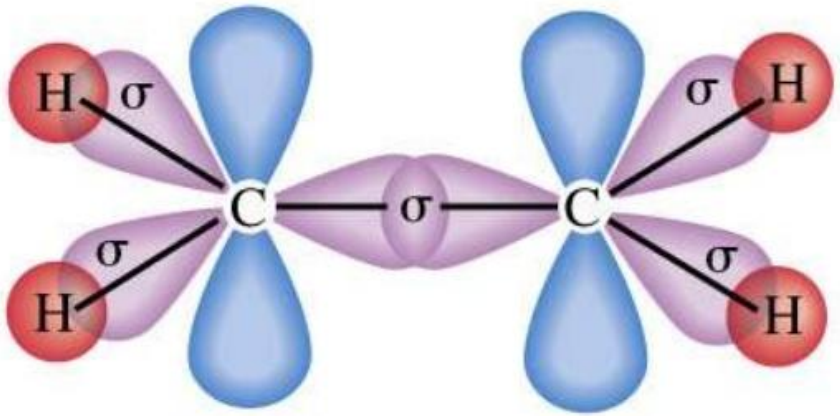
Since carbon forms 3 sigma bonds, it will mix 3 of its valence orbitals (2s, $2p_x$, $2p_y$) to form 3 identical orbitals with equal shape and energy.




2 p
2 s
hybridize
3 sp2 orbitals + 1 p
3 orbitals mixed
3 orbitals formed

The name of the hybridised orbitals will be sp^2 hybridised orbitals and since they have the same shape and energy, they repel each other equally and give sp^2 hybridised carbon in C_2H_4 its trigonal planar shape.

Remainder $2p_z$ orbital is unhybridised and is used in pi bond formation.

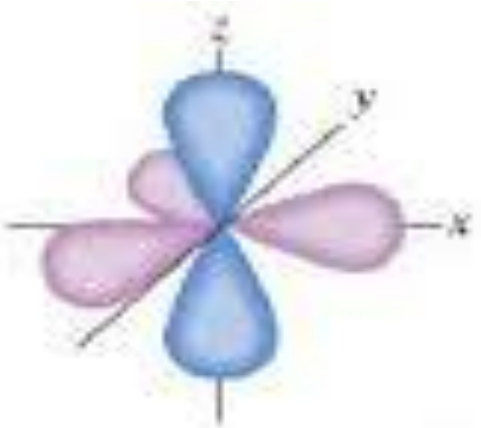


Each carbon : 3 hybridized sp^2 orbitals and 1 p orbital

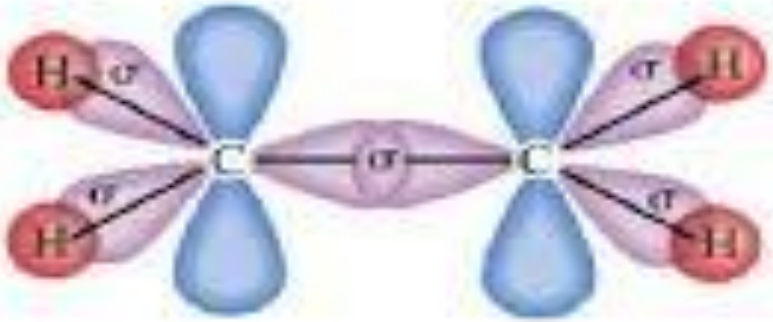
Sigma bond – single bond C-H

Sigma bond – sp^2 orbitals: one half of double bond C=C

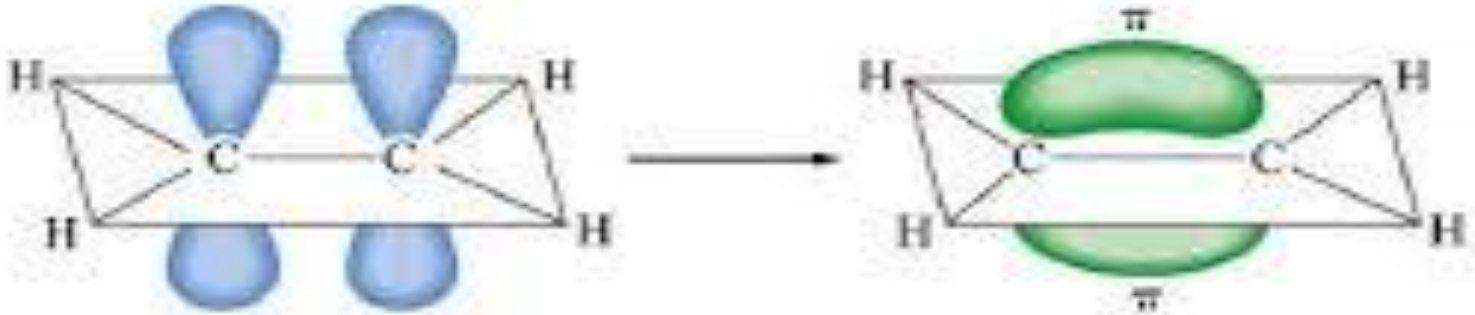
Pi bond – p orbitals: other half of double bond C=C



The set of orbitals $sp^2 + p$



Sigma (σ) bonds



Overlap of p orbitals leading to pi (π) bond

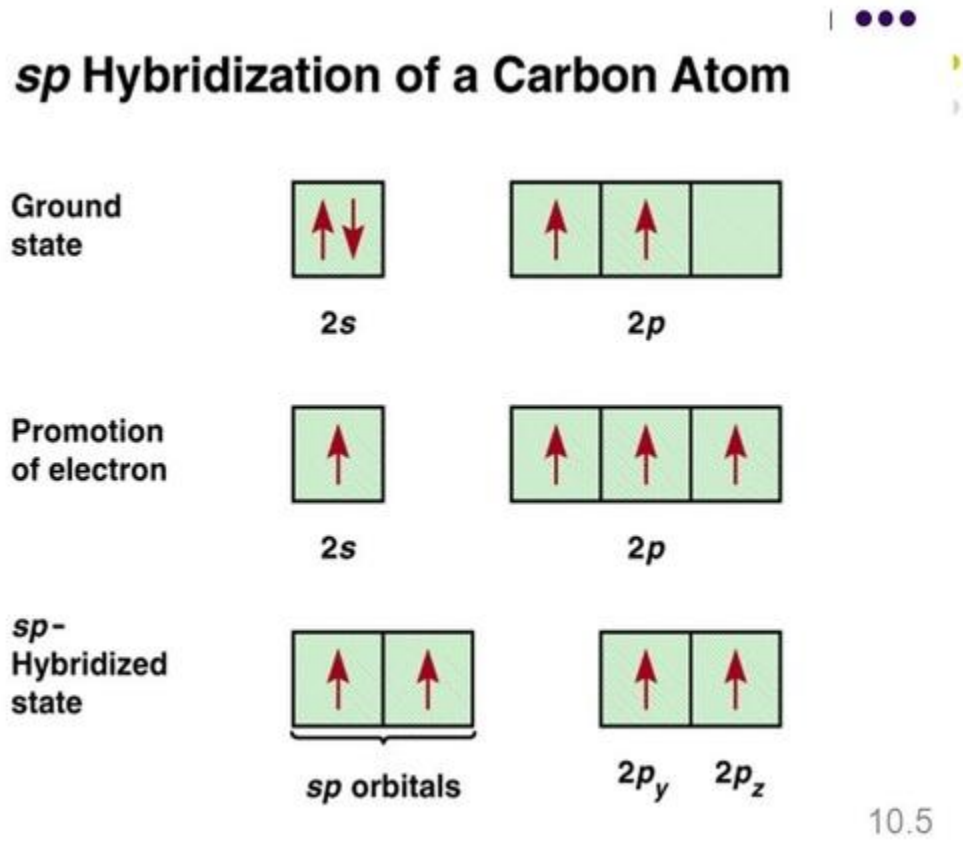
sp^2 Hybridization

A carbon atom is sp2 hybridized when bonding takes place between one s-orbital with two p orbitals. There is a formation of two single bonds and one double bond between three atoms. The hybrid orbitals are placed in a triangular arrangement with 120° angles between bonds.

Hybridization of Carbon
sp Hybridization

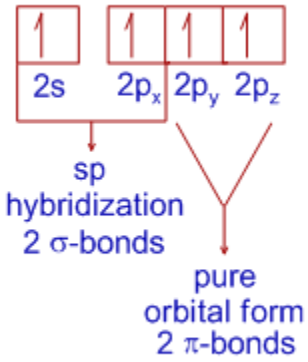
3. Ethyne, C_2H_2

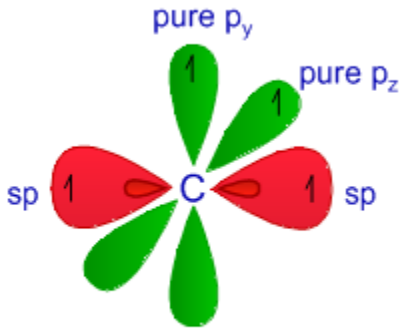
Carbon in ethyne forms two sigma bonds and two pi bonds.

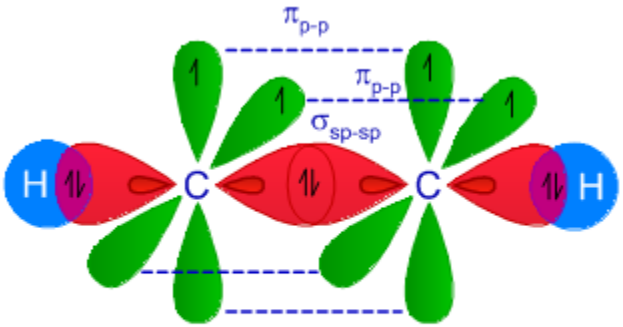


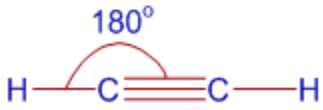
The name of the hybridised orbitals will be sp hybridised orbitals and since they have the same shape and energy, they repel each other equally and give sp hybridised carbon in C_2H_2 its linear shape.

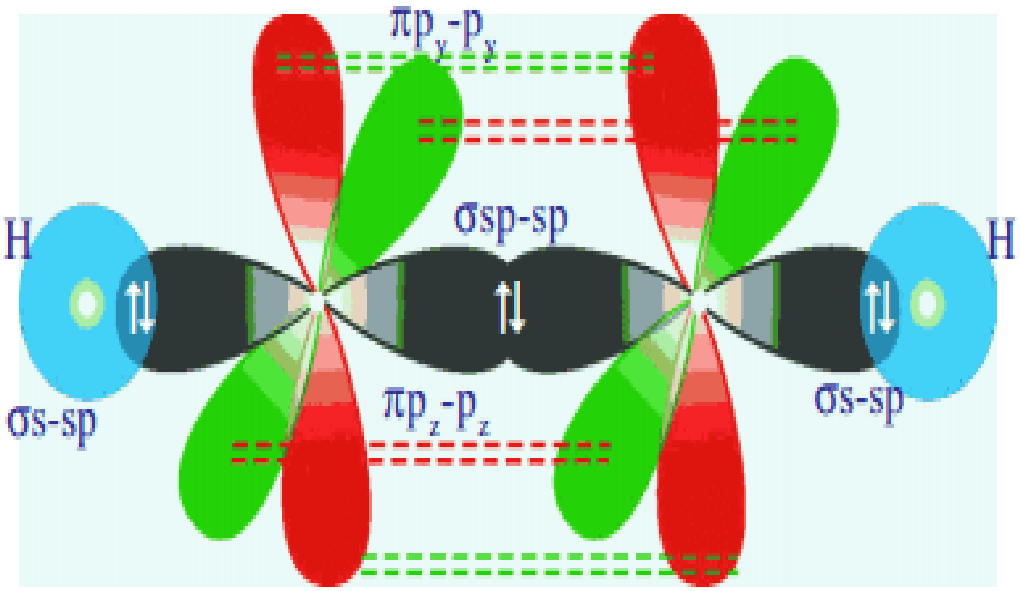
Remainder $2p_y$ and $2p_z$ orbitals are unhybridised and used in pi bond formation.


2s
2p$_x$
2p$_y$
2p$_z$
sp
hybridization
2 σ-bonds
pure
orbital form
2 π-bonds


pure p$_y$
pure p$_z$
sp
C
sp


π$_{p-p}$
π$_{p-p}$
σ$_{sp-sp}$
H
C
C
H


180°
H
C
C
H



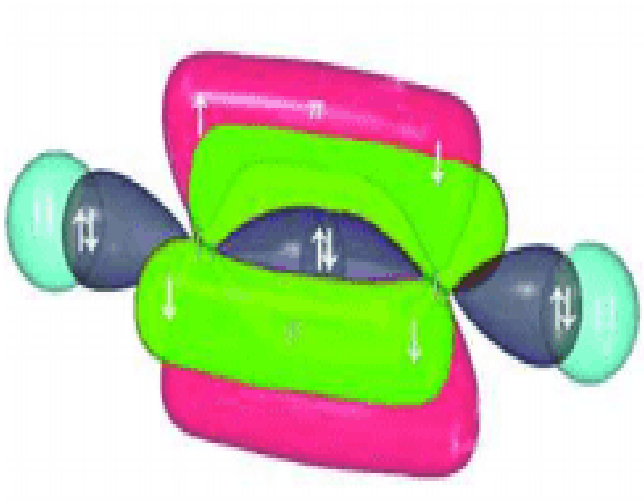


figure of C_2H_2

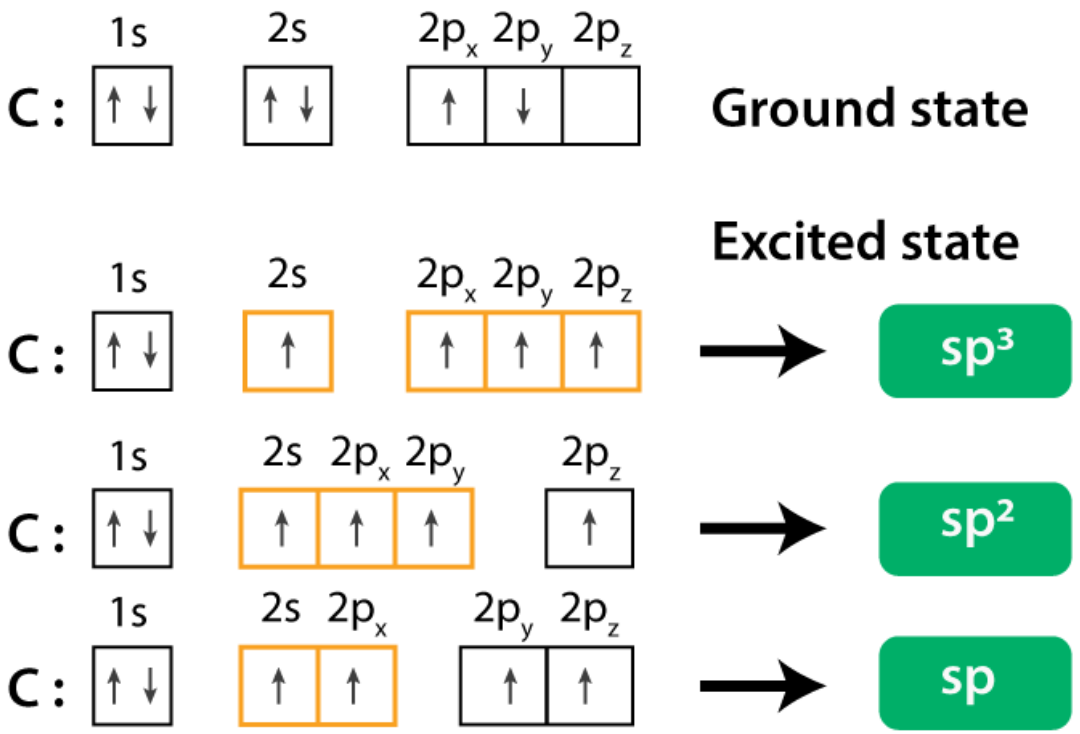
sp Hybridization

Carbon can have an sp hybridization when it is bound to two other atoms with the help of two double bonds or one single and one triple bond. When the hybridization occurs the molecules have a linear arrangement of the atoms with a bond angle of 180°.

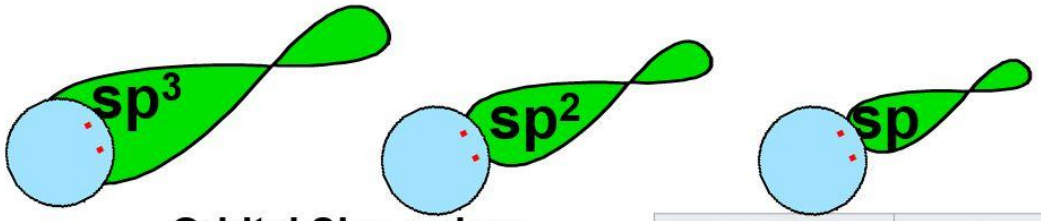
Summary for State of Hybridisation for Carbon

example	no. of σ bds	hybridisation	shape
$-\overset{|}{\underset{|}{C}}-$	4	sp^3	tetrahedral
$\diagdown C=$	3	sp^2	trigonal planar
$-C\equiv$ $=C=$	2	sp	linear

Hybridization of Carbon



Variation of electronegativity with hybridization of atom.



Orbital Size order :

$sp^3 > sp^2 > sp$

Electronegativity order:

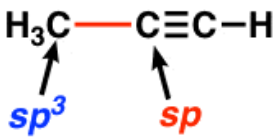
$sp > sp^2 > sp^3$

Hybridization	χ (Pauling)
C(sp^3)	2.3
C(sp^2)	2.6
C(sp)	3.1
'generic' C	2.5

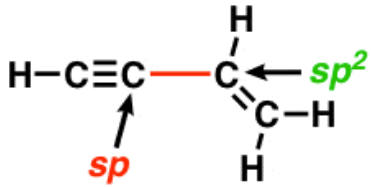
The six types of carbon-carbon σ-bonds

sp^3–sp^3 σ-bond

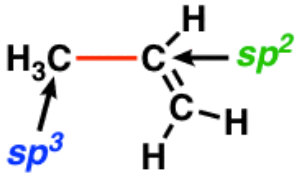
sp^3–sp σ-bond



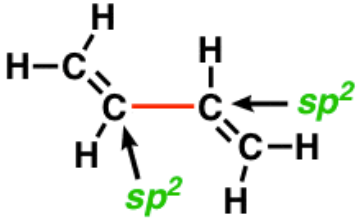
sp–sp^2 σ-bond



sp^3–sp^2 σ-bond



sp^2–sp^2 σ-bond



sp–sp σ-bond