1 A SIMPLIFIED OVERVIEW OF THE CHEMONTO METHODOLOGY

1.1 Reaction is Heck reaction as shown below:

$$PhI + CH_2 = CHPh \xrightarrow{Pd,\ PPh_3,\ N(Et)_3} (E) - Stilbene + (Z) - Stilbene + 1,1 - diphenylethylene$$

Steps to construct CHEMONTO knowledge:

Step: (1) Read the setup file in XYZ format. Step: (2) SUI Identification. Step: (3) Chemical Unit Identification, Step: (4) Reaction Center Identification, Step: (5) Constructing the hybridization of atoms.

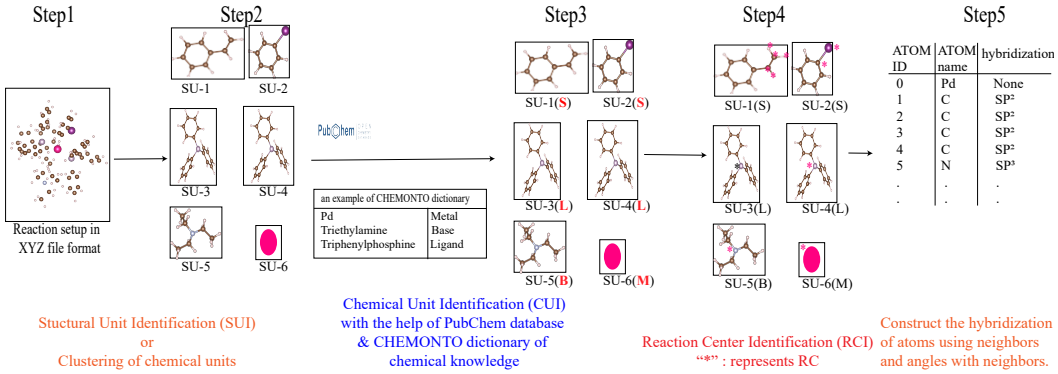


Fig. 1. The five basic steps of CHEMONTO . Step 1 corresponds to reading the setup file. Steps 2 and 3 address SUI and CUI, respectively. There are a total of six SUs. Step 3 further includes RCI; for example, the substrate PhI contains two RCs, styrene contains five RCs, while a ligand, a base, and a metal each contain one RC. The label M represents metal, L represents ligand, B represents base, and S represents substrate.

1.2 An example of ERPO of oxidative addition which provides paths to AFIR

$$(1)\ L_2Pd + PhI \xrightarrow{association} L_2Pd\cdots PhI \qquad \left(\equiv L_2Pd \begin{matrix} I \\ | \\ \diagdown \\ \diagup \\ Ph \end{matrix} \right)$$

$$(2)\ PhI \xrightarrow{dissociation} Ph + I$$

$$(3)\ L_2Pd + Ph \xrightarrow{association} L_2Pd - Ph$$

$$(4)\ L_2Pd - Ph + I \xrightarrow{association} L_2Pd \begin{matrix} \diagup Ph \\ \diagdown I \end{matrix}$$

In all the steps, it is assumed that both the Ls are attached to Pd. Steps (3) and (4) can be interchanged.

1.3 The use of ERPO in section 1.2 to find oxidative addition from reaction network:

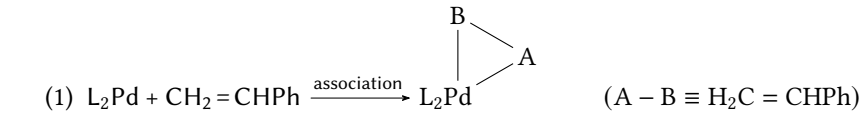
(1) In ERPO definition of oxidative addition (section 1.2), the first option is not required for checking the completion of oxidative addition.

(2) $d(I_{Id}, Ph_{Id}) > \delta$,

(3) $d(Pd_{Id}, Ph_{Id}) < \delta$,
(4) $d(Pd_{Id}, I_{Id}) < \delta$,

where Pd_{Id}, Ph_{Id}, and I_{Id} are the reaction centers of Pd, Ph, and I, respectively (Figure 1, step 4), and d(X,Y) measures Euclidean distance between X and Y. $\delta = 3.0$ Å. During the evaluation of the above distance criteria, atomic hybridizations are additionally considered to verify the validity of each SU through the allowed_changes option. For further details, please refer to the main manuscript.

1.4 Another example of ERPO of olefin insertion which provides paths to AFIR



1.5 The use of ERPO in section 1.4 to find olefin insertion from reaction network:

(1) $d(Pd_{Id}, C1_{Id}) < \delta$,
(2) $d(Pd_{Id}, C2_{Id}) < \delta$,

where $C1_{Id}$ and $C2_{Id}$ represent atom IDs of two olefin carbon atoms. $\delta = 3.0$ Å. During the evaluation of the above distance criteria, atomic hybridizations are additionally considered to verify the validity of each SU through the allowed_changes option.

Similarly, other ERPOs can be built. Since the conditions for oxidative addition and olefin insertion are checked separately, their overlap leads to the idea of overlapping ERPOs.