How to choose the best catalyst

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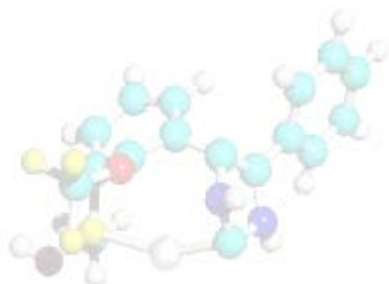
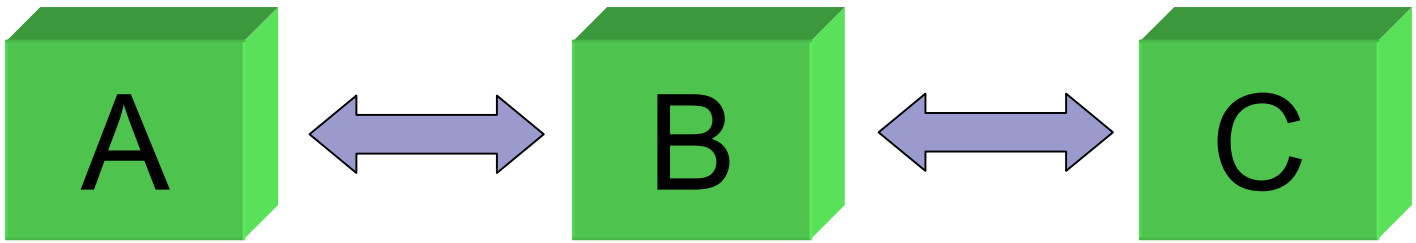
What do we want?

- Optimize catalysts to get the best performance
- Problem:
  - How to get diversity?
  - Only few possible candidates can be synthesized and tested
- Solution: optimization by computer

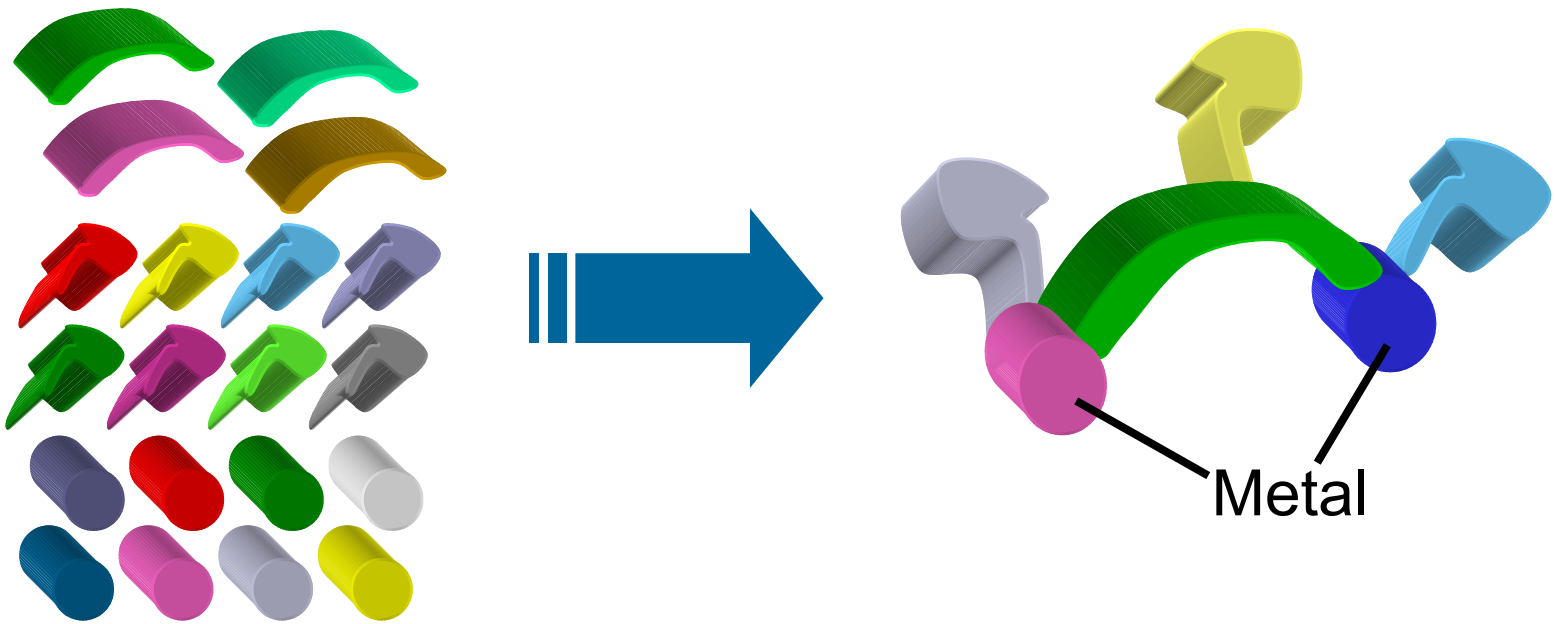


General Idea

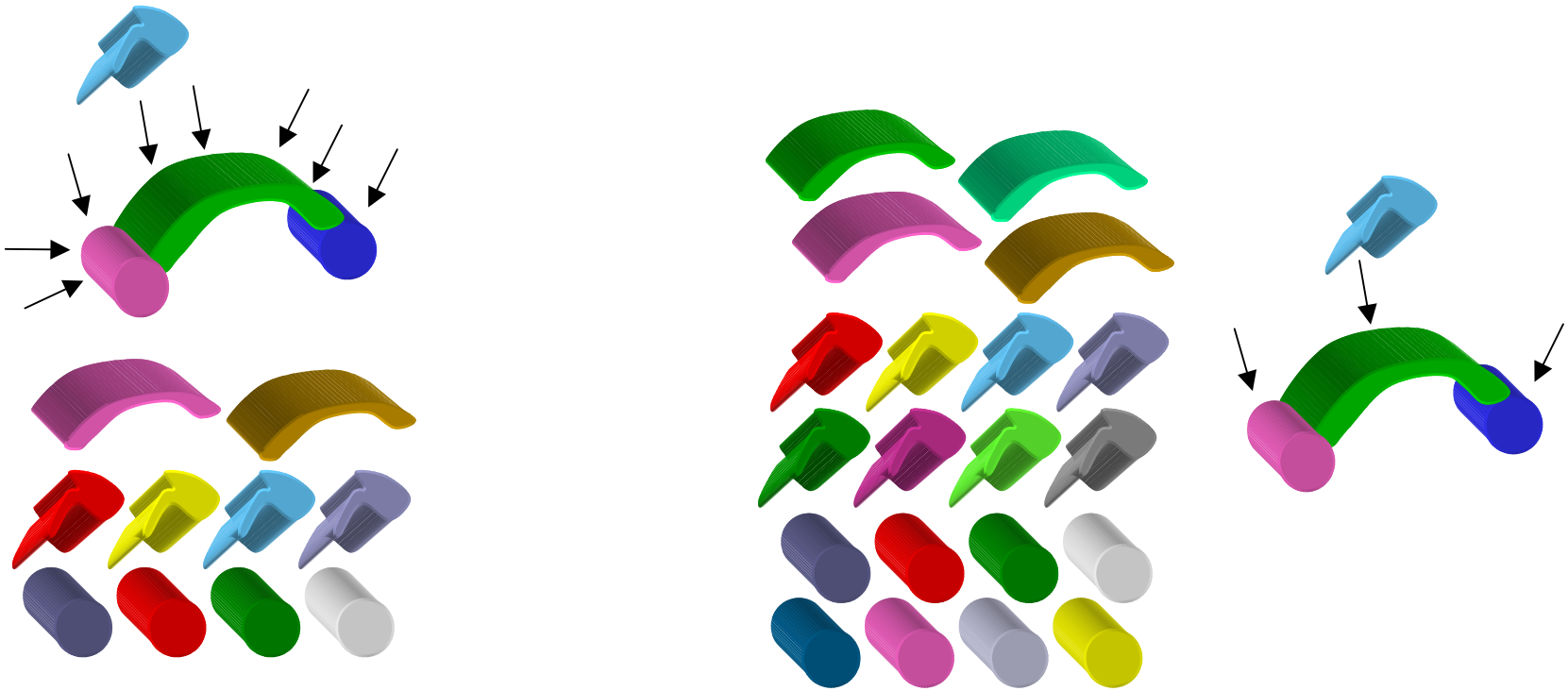


Imagine three multi-dimensional spaces ‘A’, ‘B’, and ‘C’. Space ‘A’ contains all of the possible catalysts; Space ‘B’ contains their molecular descriptors, and space ‘C’ contains their activities etc.

Space ‘A’ for bidentate catalysts

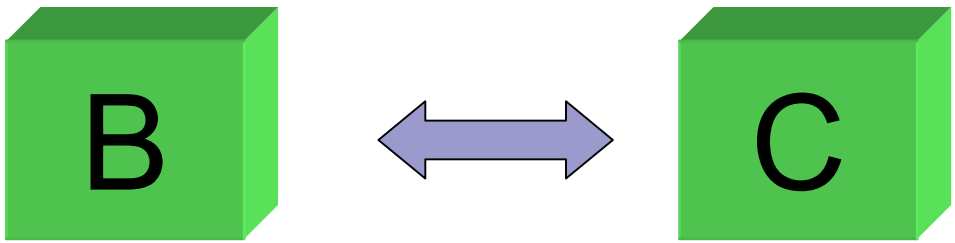


What about diverse catalysts?



It is not so clear what is ‘diversity’ in this case, or how to obtain it.

Spaces ‘B’ and ‘C’



descriptors

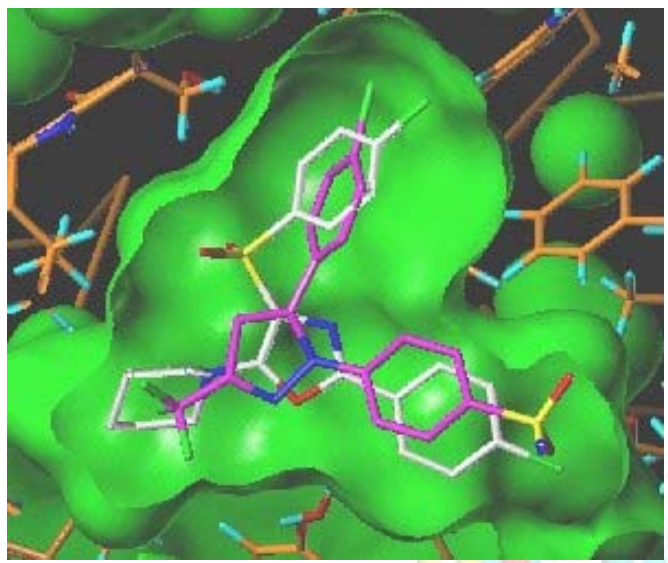
figures of merit

Molecular size;
Backbone flexibility;
Bite angle;
Lipophilicity;
Temperature;
Pressure;
Solvent;
…

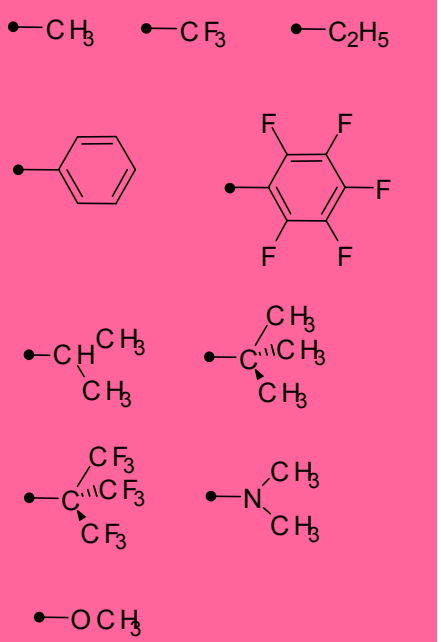
Structure-activity links

- Already solved: Quantitative Structure-Activity Relationship (QSAR) models can be used to link spaces ‘B’ and ‘C’.

- QSAR is well known tool from e.g. pharmaceutical applications

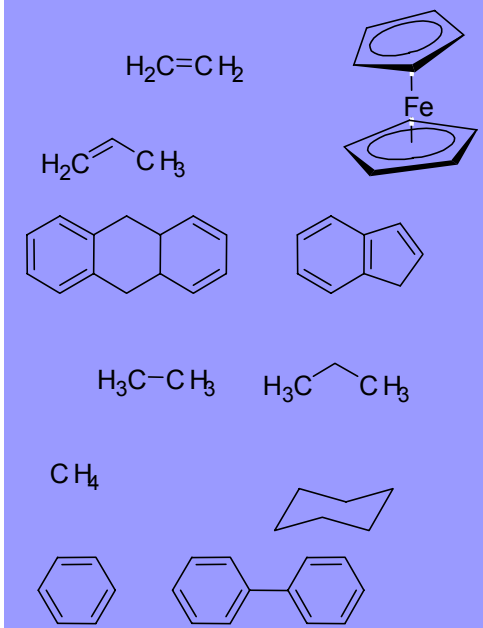


Example

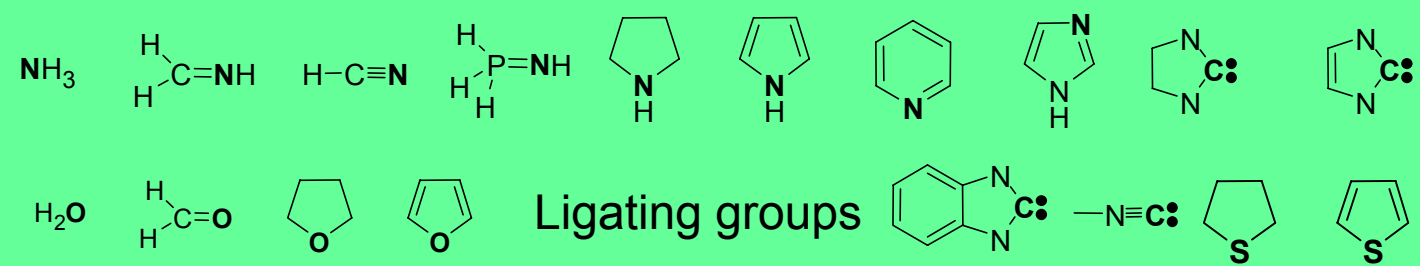


Residue groups

Bidentate catalyst scheme



Bridging groups



Catalyst search space

- 19 ligating groups
- 10 bridging groups
- 10 residue groups

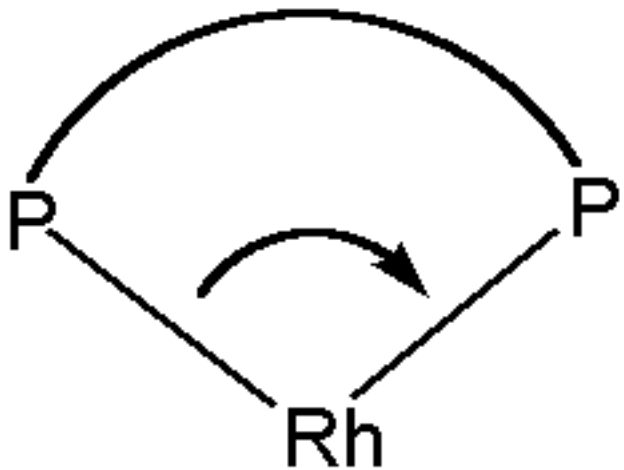
} multiple connection points

- All simple & cheap building blocks

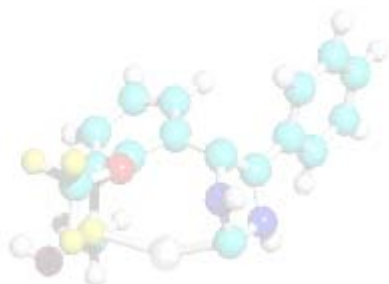
- Total 1.714.176.000 compounds!
- (one structure for every Chinese person!)

Example

- Demonstration of principle:
- Prediction of Bite Angle



- Bite angle is directly related to activity

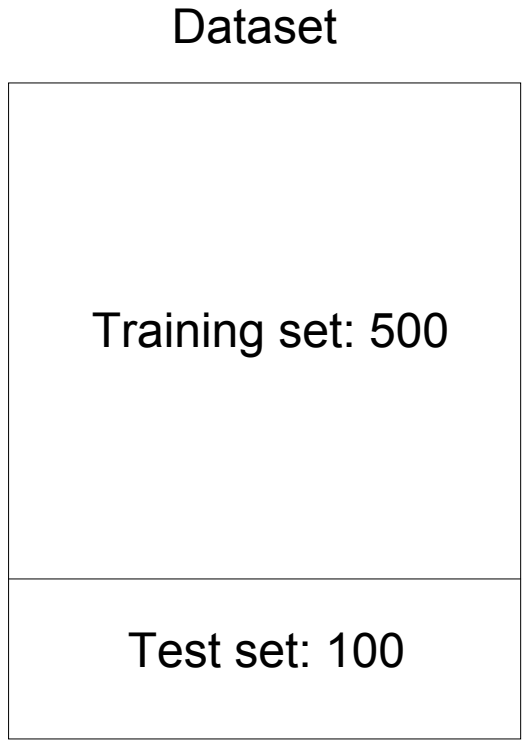


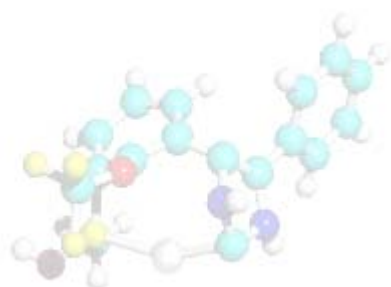
Example: procedure

- Choose building blocks
- Generate 600 random catalyst structures
  - Matlab: 5 minutes
- Geometry optimization with Hyperchem
  - Fully automated, 30 secs per structure
- Calculation of QSAR parameters with Codessa
  - +/- 30 minutes

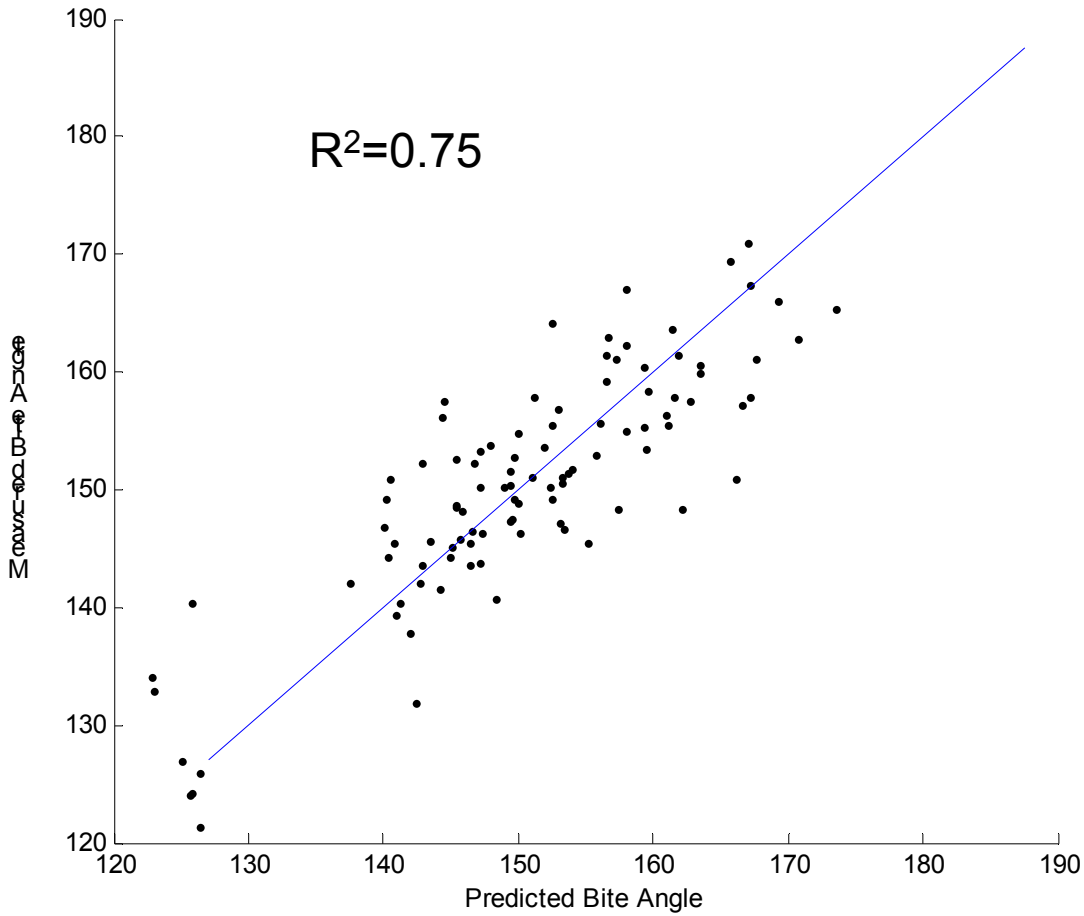
Example: procedure

- Model creation (PLS) of bite angle with training set (500 structures)
- Model validation with 100 test structures

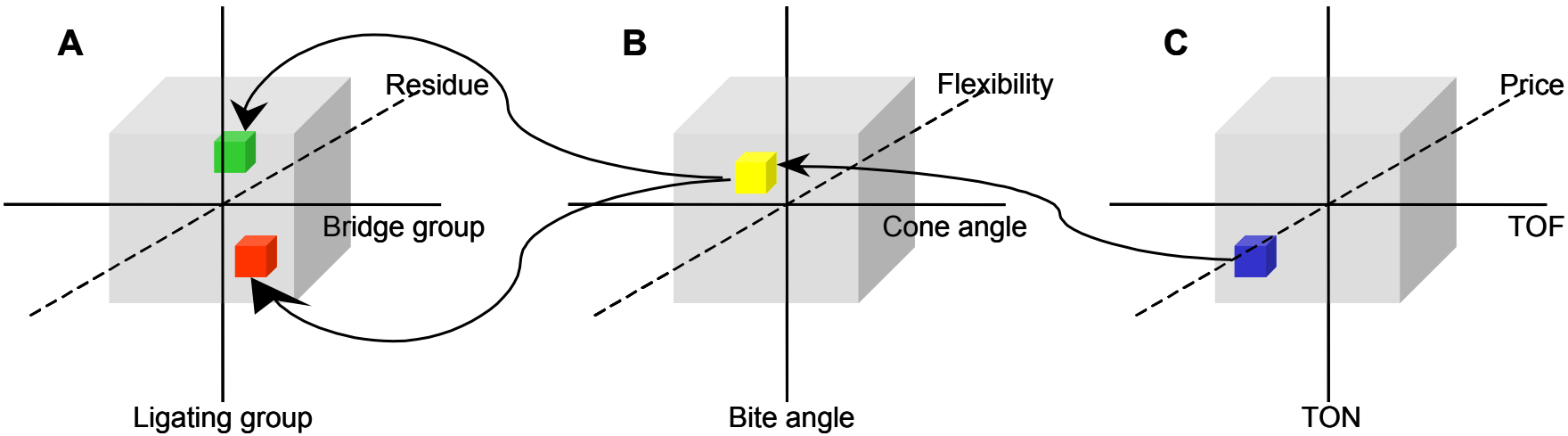




Bite Angle results



Interesting: can we go back?



Conclusions or ‘How can you benefit’?

- Easy creation of diverse set of catalysts
- Prediction of activity of catalysts without actual synthesis
- Two way: circumvent patented catalysts from other companies