Biocatalytic Synthesis

Examples of reactions investigated at the

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biocatalytic synthesis

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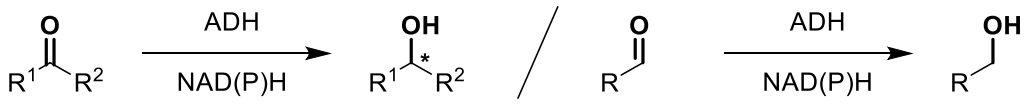
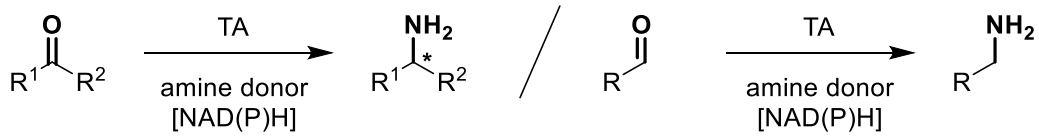
Reductive Biotransformations

Reduction of Aldehydes and Ketones



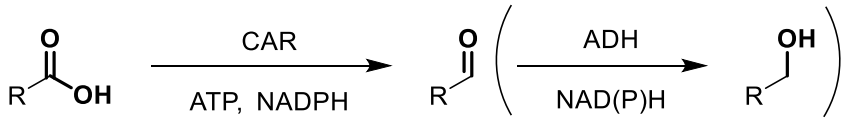
*(ADH = alcohol dehydrogenase; Angew. Chem., Int. Ed. **2002**, 41, 1014; Angew. Chem., Int. Ed. **2008**, 47, 714; ChemCatChem **2013**, 5, 1744.)*

Reductive Amination of Aldehydes and Ketones



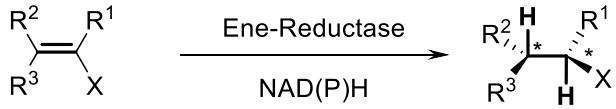
*(TA = ω-transaminase; Angew. Chem., Int. Ed. **2008**, 47, 9337; Angew. Chem., Int. Ed. **2012**, 51, 9156; Org. Proc. Res. Dev. **2013**, 17, 751; ACS Catal. **2014**, 4, 129.)*

Reduction of Carboxylic Acids



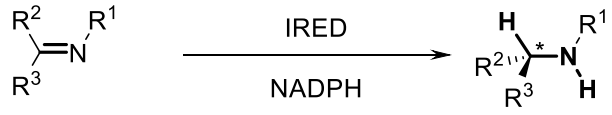
*(CAR = carboxylate reductase, ADH = alcohol dehydrogenase; Chem. Monthly, **2016**, 147, 575.)*

Reduction of C=C-Bonds



*(X = electron-withdrawing group; Angew. Chem., Int. Ed. **2007**, 46, 3934; Chem. Eur. J. **2012**, 18, 10367; Curr. Opin. Chem. Biol. **2007**, 11, 203; J. Biotechnol. **2012**, 162, 381; Nat. Commun. **2014**, 5, 4150; Curr. Opin. Chem. Biol. **2018**, 43, 97)*

Reduction of Imines

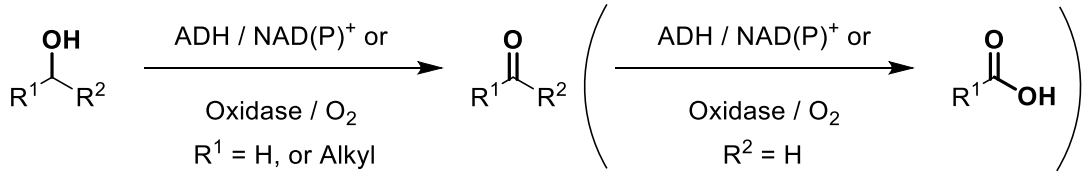


*(IRED = imine reductase; Adv. Synth. Catal. **2015**, 357, 1655; ChemCatChem **2018**, 10, 3236.)*

biocatalytic synthesis

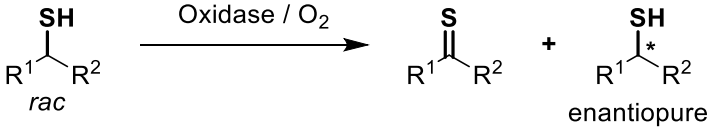
Oxidative Biotransformations

Oxidation of Alcohols / Aldehydes



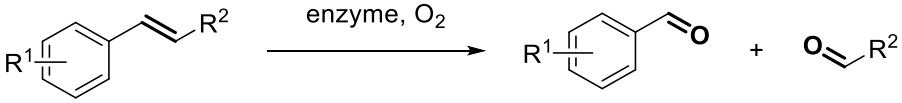
(ADH = alcohol dehydrogenase; Angew. Chem., Int. Ed. ***2002****, 41, 1014; Angew. Chem., Int. Ed.* ***2008****, 47, 714; J. Am. Chem. Soc.* ***2008****, 130, 13969; ChemCatChem* ***2013****, 5, 1744.)*

Oxidation of Thiols



(Angew. Chem., Int. Ed. ***2018****, 57, 2864.)*

C=C-Bond Cleavage

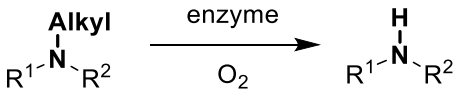


(Angew. Chem., Int. Ed. ***2006****, 45, 5201; J. Am. Chem. Soc.* ***2009****, 131, 5368; Chem. Commun.* ***2012****, 48, 3303; Adv. Synth. Catal.* ***2015****, 357, 3309; Front. Microbiol.* ***2016****, 7, 1511.)*

De-Amination

(TA = ω-transaminase; AO = α-amino oxidase; Angew. Chem., Int. Ed. ***2008****, 47, 9337; Org. Proc. Res. Dev.* ***2013****, 17, 751; ACS Catal.* ***2014****, 4, 129.)*

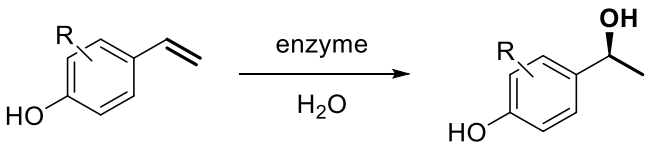
N-De-Alkylation



(Angew. Chem., Int. Ed. ***2015****, 54, 15051.)*

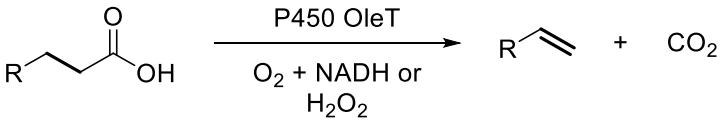
Oxidative Biotransformations

Hydration of Styrenes



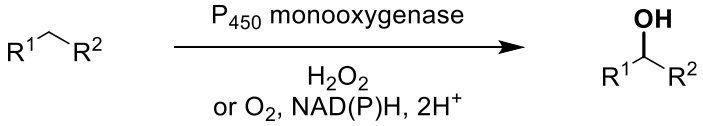
*(Angew. Chem., Int. Ed. **2013**, 52, 2293; ACS Catal. **2018**, 8, 2438.)*

Oxidative Decarboxylation



*(Angew. Chem., Int. Ed. **2015**, 54, 8819; Chem. Commun., **2016**, 51, 1918; Eur. J. Org. Chem., **2016**, 2473; Eur. J. Org. Chem. **2016**, 3473.)*

C-H Hydroxylation



terpenoid, steroid, APIs

*(Angew. Chem., Int. Ed. **2006**, 45, 5201; J. Am. Chem. Soc. **2009**, 131, 5368; Chem. Commun. **2012**, 48, 3303; Adv. Synth. Catal. **2013**, 355, 3321; Angew. Chem. Int. Ed. **2018**, 57, 427; Catal. Lett. **2018**, 148, 787)*

Baeyer-Villiger Oxidation

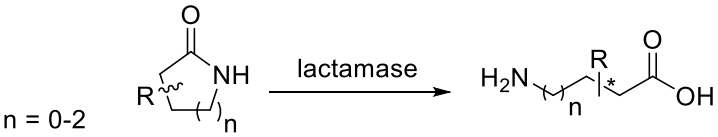
R^1 = H, or Alkyl
R^2 = Alkyl or Aryl

n = 1,2
R = Alkyl

*(hFMO = human flavin containing monooxygenase; ACS Chem. Biol., **2016**, 11, 1039; ACS Chem. Biol. **2017**, 12, 2379.)*

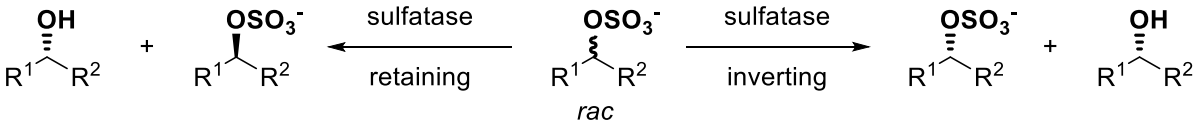
Hydrolysis / Esterification

Hydrolysis of Lactams



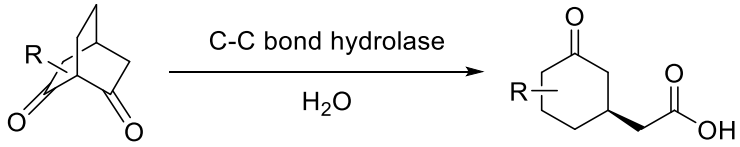
*(ChemCatChem **2014**, 6, 2517.)*

Bio-Mitsunobu-Inversion



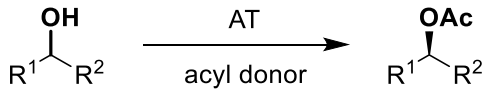
*(Angew. Chem., Int. Ed. **2002**, 41, 1014; Angew. Chem., Int. Ed. **2005**, 44, 6381; Angew. Chem., Int. Ed. **2013**, 52, 3277; Eur. J. Org. Chem. **2013**, 356; Trends Biotechnol. **2013**, 31, 468; Appl. Microbiol. Biotechnol. **2014**, 4, 1485.)*

C-C-Bond Hydrolysis



*(Adv. Synth. Catal. **2013**, 355, 1677; Adv. Synth. Catal. **2013**, 355, 1703; Top. Catal. **2014**, 57, 376.)*

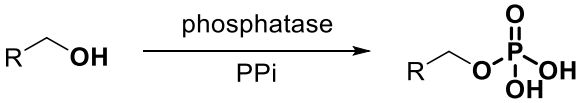
Ester-Formation in Aqueous Systems



R^1, R^2 = alkyl

*(AT= acyl transferase; ACS Catal. **2018**, 8, 10698.)*

Phosphorylation



*(PPi = pyrophosphate; Eur. J. Org. Chem., **2016**, 45; J. Biotechnol. **2016**, 233, 219; Adv. Synth. Catal. 2018, 360, 2394.)*

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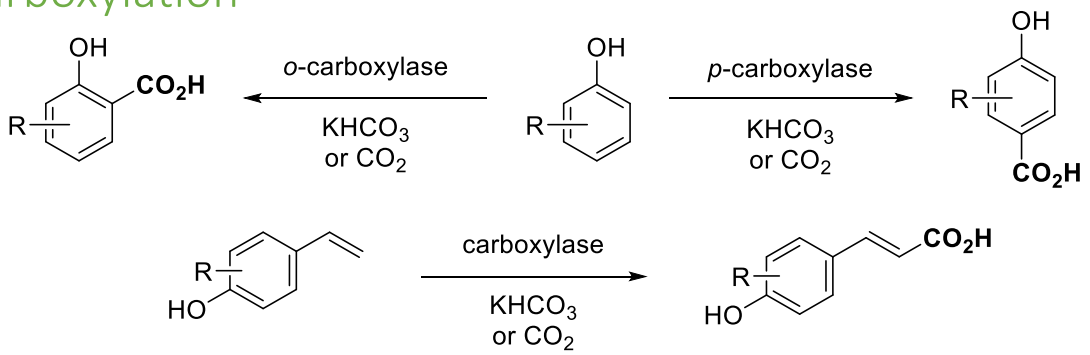
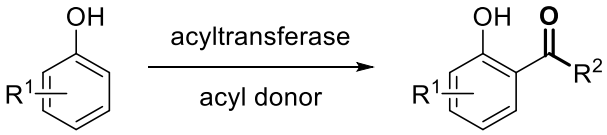
Biocatalytic C-C-Bond Formation

Carboxylation



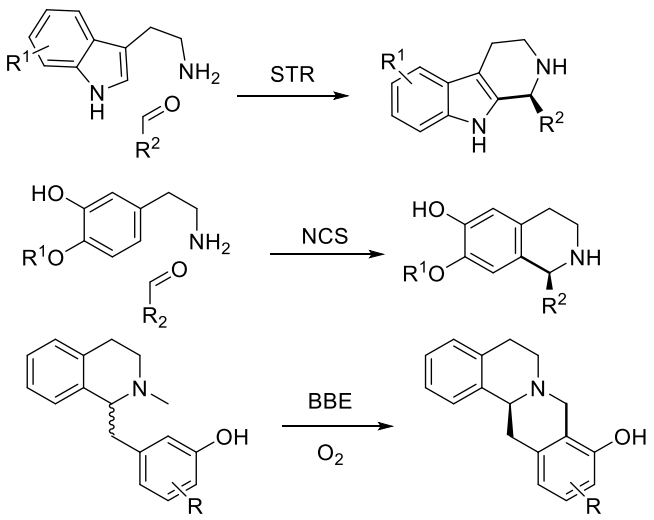
*(Chem. Soc. Rev. **2010**, 39, 313; Org. Lett. **2012**, 14, 1974; J. Biotechnol. **2013**, 168, 264; RSC Adv. **2014**, 4, 9673; Angew. Chem. Int. Ed. **2017**, 56, 13893.)*

Friedel-Crafts Acylation



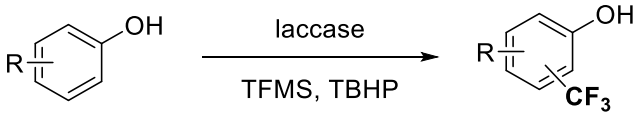
*(Angew. Chem. Int. Ed. **2017**, 56, 7615.)*

Alkaloid Synthesis



*(BBE = berberine bridge enzyme; STR = strictosidine synthase; NCS = norcoclaurine synthase; Angew. Chem., Int. Ed. **2011**, 50, 1068; Org. Proc. Res. Dev. **2013**, 17, 751; Angew. Chem., Int. Ed. **2014**, 53, 3731; ACS Catal. **2016**, 6, 23; Angew. Chem. Int. Ed. **2018**, 57, 10683.)*

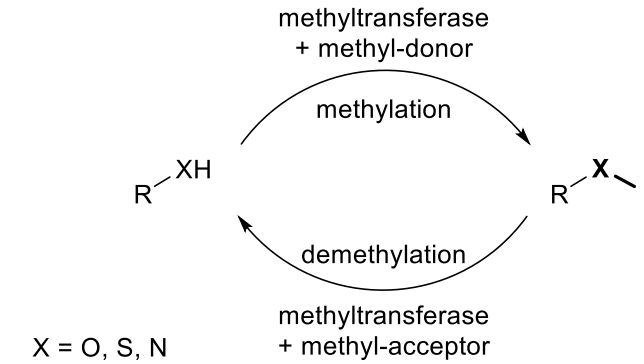
Trifluoromethylation



*(TFMS = trifluoromethylsulfonic acid; TBHP = t-butylhydroperoxide; Nat. Commun. **2016**, 7, 13323.)*

Biocatalytic C-O-Bond Formation and Cleavage

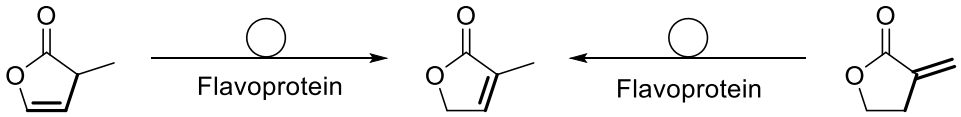
Methylation and De-Methylation



*(Communs. Chem., **2018**, 1, 82.)*

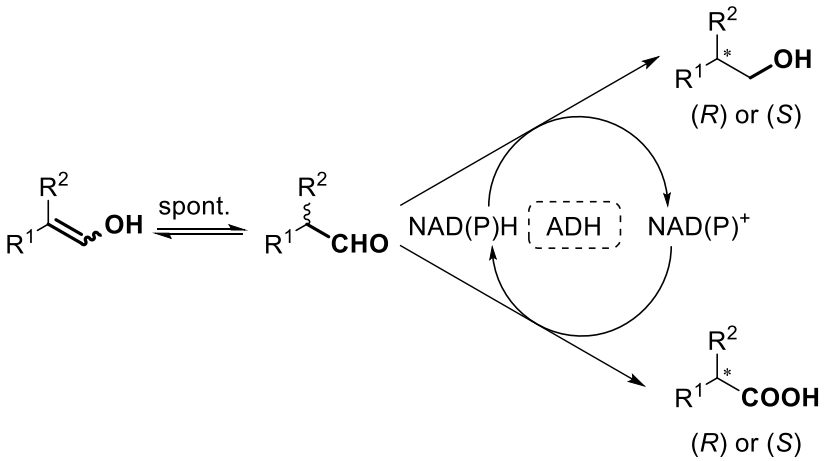
Enzymatic Isomerisation

Isomerisation of C=C-Bonds



*(ChemBioChem, **2012**, 13, 2346; ChemSusChem **2016**, 9, 3393.)*

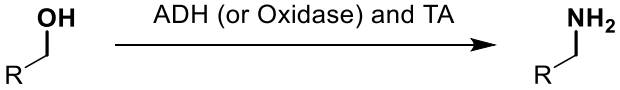
Disproportionation: Biocatalytic Cannizzaro Reaction



*(ADH = alcohol dehydrogenase; ChemCatChem, **2013**, 5, 1744; Adv. Synth. Catal. **2018**, 360, 2742.)*

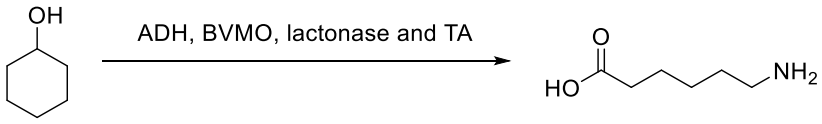
Enzymatic Cascades

Direct Amination of Alcohols



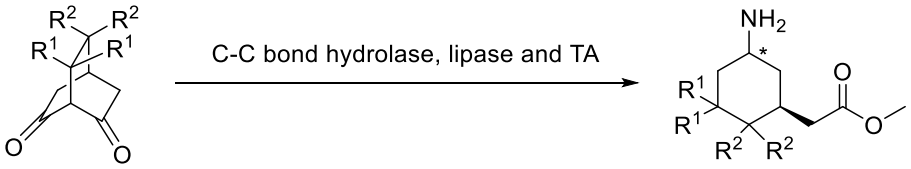
*(ADH = alcohol dehydrogenase; TA = transaminase; ChemCatChem **2015**, 7, 3121; Angew. Chem., Int. Ed. **2012**, 51, 9156; ACS Catal. **2014**, 4, 129.)*

6-Aminohexanoic Acid from Cyclohexanol



*(ADH = alcohol dehydrogenase; BVMO = Baeyer-Villiger monooxygenase, TA = transaminase; Angew. Chem., Int. Ed. **2014**, 53, 14153; ACS Catal. **2014**, 4, 129.)*

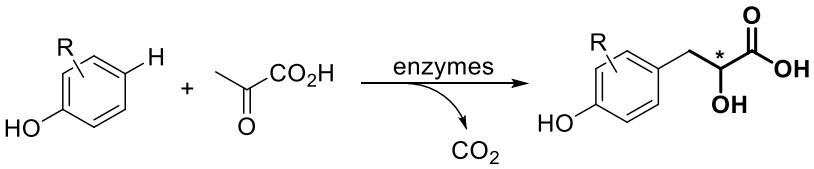
Cyclohexylamines from Diketones



*(TA = ω-transaminase; Adv. Synth. Catal. **2013**, 355, 1703.)*

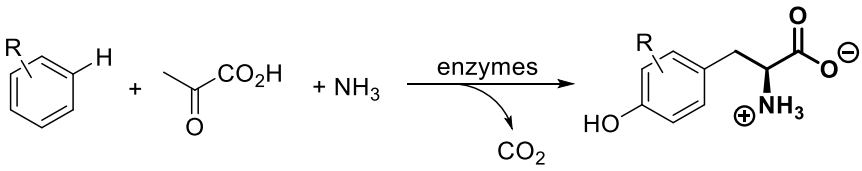
Enzymatic Cascades

Enantio-Pure Lactic Acids from Phenols



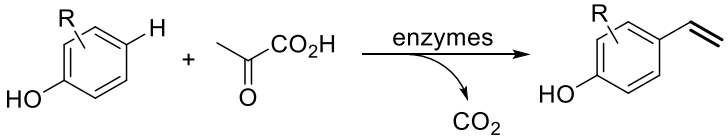
*(ACS Catal. **2016**, 6, 2393.)*

L-Tyrosine Derivatives from Benzenes



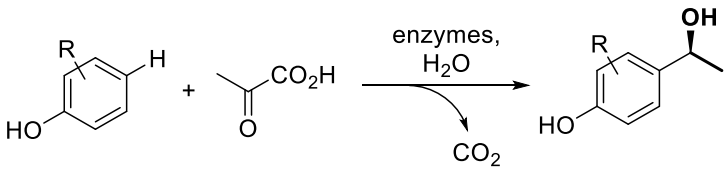
*(ACS Catal. **2015**, 5, 7503.)*

Vinylation of Phenols



*(Angew. Chem., Int. Ed. **2015**, 45, 10899.)*

Hydroxyethylation of Phenols



*(Org. Lett. **2018**, 20, 5139.)*