

Abbreviations

Ar	aryl
atm.	atmosphere
bmim	1-butyl-3-methylimidazolium
BSA	<i>N,O-bis</i> (trimethylsilyl)acetamide
Bu	butyl
cat.	catalyst
Cy	cyclohexyl
dba	dibenzylideneacetone
DCM	dichloromethane
DMF	dimethyl formamide
DMM	dimethyl maleate
dppp	1,3- <i>bis</i> (diphenylphosphino)propane
ee	enantiomeric excess
equiv	equivalents
Et	ethyl
EtOAc	ethyl acetate
FBS	fluorous biphasic system
GC-MS	gas chromatography-mass spectrometry
HOMO	highest occupied molecular orbital
L	ligand
LUMO	lowest unoccupied molecular orbital
MAO	methylaluminoxane
Me	methyl
NMR	nuclear magnetic resonance
Nu	nucleophile
OAc	acetate
Ph	phenyl
Pr	propyl

r.t.	room temperature
THF	tetrahydrofuran
TLC	thin layer chromatography
TOF	turnover frequency
TON	turnover number
Ts	tosyl



Synopsis

The main objective of the research described in this dissertation, was the optimisation of reaction conditions for various palladium(0)-catalysed Heck-type reactions, and the development and application of bidentate iminophosphine ligands for some of these reactions.

The efficiency of Heck and Heck-type reactions was evaluated by comparison of various parameters, *e.g.* solvent, palladium salt, reaction temperature and ligands for these palladium salts. In most cases, DMF was used as solvent, and palladium acetate served as a source of catalyst. Reactions were mostly carried out at 110 °C, and triphenylphosphine was used as the bench mark monodentate ligand, while 1,3-bis(diphenylphosphino)propane (dppp) was applied as a bench mark for the performance of bidentate ligands. Apart from the Heck reaction between aryl halides and olefins, palladium-catalysed esterification reactions, transmetallation reactions and intramolecular reactions were investigated.

A series of iminophosphine ligands was synthesised *via* the condensation of 2-(diphenylphosphino)benzaldehyde with primary amines. Although these ligands are thermally stable, they are extremely susceptible towards oxidation. This problem of oxidation, together with their instability on silica, led us to the development of specialised techniques to isolate and purify the ligands. Distillation of these ligands under vacuum, together with the simultaneous subjection of the distillation apparatus to an inert argon atmosphere, resulted in the isolation of pure, unoxidised iminophosphine ligands.

Application of the synthesised iminophosphine ligands to the optimised Heck reaction, indicated that these ligands were catalytically active. A series of Heck reactions employing different aryl halides, was chosen to test the efficiency of the newly synthesised ligands. In the cases of iodobenzene and *o*-nitroiodobenzene, similar results were obtained for triphenylphosphine, the iminophosphine ligands, and dppp. However,

in the case of *p*-bromobenzonitrile, where the oxidative addition of palladium to the C-Br bond is slower than for corresponding C-I bonds, the efficiency of the iminophosphine ligands could clearly be seen in the higher yields that were obtained in comparison to the bench mark ligands. Further development of bidentate P-N ligands with different electronic characteristics, and application of these ligands with palladium and other transition metals for catalysis, is a field of research that should not be left unexplored.



Samevatting

Die tweeledige doel van die navorsing soos beskryf in hierdie verhandeling, het die optimering van reaksie kondisies vir verskeie palladium(0)-gekataliseerde Heck-tipe reaksies, en die ontwikkeling en toepassing van bidentate imienofosfien ligande vir sommige van dié reaksies, behels.

Die sukses van Heck en Heck-tipe reaksies is geëvalueer deur verskeie parameters te vergelyk, naamlik oplosmiddel, palladium sout, temperatuur van reaksies, en die verskillende ligande vir die palladium soude. DMF is in die meeste gevalle gebruik as oplosmiddel, en palladium asetaat is gebruik as bron van katalisator. Reaksies is meesal uitgevoer teen 'n temperatuur van 110 °C, en trifenielfosfien is gebruik as standaard monodentate ligand, terwyl 1,3-bis(difenielfosfien)propaan (dppp) gebruik is as standaard bidentate ligand waarmee ander ligande dan vergelyk is. Buiten vir die Heck reaksie tussen ariehaliede en alkene, is ander palladium-gekataliseerde reaksies soos esterifiserings reaksies, transmetalleringreaksies en intramolekulêre reaksies ook uitgevoer.

Die sintese van 'n reeks van iminofosfien-ligande is ontwikkel deur die kondensasiereaksie tussen 2-(difenielfosfien)bensaldehyd en primêre amiene. Hoewel dié ligande termies stabiel is, is hulle uiters vatbaar vir oksidasie. Die oksidasie-probleem, tesame met die feit dat hierdie ligande onstabiel is op silika, het gelei tot die ontwikkeling van gespesialiseerde tegnieke om die ligande suiwer te isoleer. Die ligande is onder vakuum gedistilleer, terwyl die distillasie-apparaat omring is met 'n atmosfeer van inerte argon. Dit het gelei tot die isolasie van suiwer ligande sonder dat oksidasie plaasgevind het.

Gebruik van die nuwe iminofosfien-ligande in die geoptimeerde Heck reaksie, het getoon dat die ligande wel katalities aktief is. 'n Reeks van Heck reaksies wat verskillende ariehaliede gebruik, is uitgekies sodat die doeltreffendheid van die nuwe ligande getoets kon word. In die gevalle van jodobenseen en *o*-nitrojodobenseen, is resultate soortgelyk

aan dié vir trifenielfosfien en dppp verkry. Dit was egter in die geval van *p*-bromobensonitriël waar die sukses van die ligande duidelik gesien kon word. Die oksidatiewe invoeging van palladium in 'n C-Br binding vind stadiger plaas as in 'n ooreenstemmende C-I binding, en in die gevalle waar die iminofosfien-ligande gebruik is, was die opbrengste van die reaksies heelwat hoër as in die gevalle waar trifenielfosfien of dppp gebruik is. Verdere ontwikkeling van bidentate P-N ligande wat ander elektroniese eienskappe het, en die toepassing van dié ligande in katalise van palladium en ander oorgangsmetale, verskaf 'n analoë navorsingsveld wat nie onaangeraak gelaat mag word nie.

