

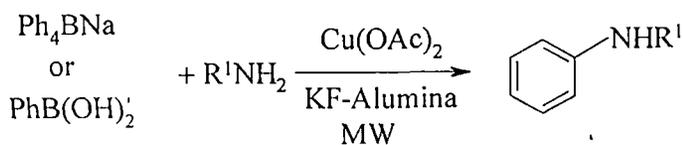
SUMMARY

Investigations embodied in this dissertation entitled "**New Reactions and Methodology: Studies on Transition Metal Catalyzed Organic Transformations**" were initiated on May 01, 2001 under the supervision of Professor B. Basu, Department of Chemistry, North Bengal University, Darjeeling-734 430.

The work carried out in this thesis is divided into four chapters; and chapters -I, III and IV are divided into two sections. The principal theme of this thesis is the application of transition metal-catalyzed organic reactions on solid surfaces. The inorganic oxides impregnated with fluoride anion (e. g. KF-Alumina), Silica gel and resin-bound formate have been employed in various organic transformations.

The first chapter (**Chapter-I**) is divided into two sections. **Chapter-I, Section-A** describes **microwave-assisted copper promoted *N*-arylation of amines using aryl boronic acids / salts on a KF-alumina surface**. Aryl amines are an important class of compounds and are widely used as drugs, dyes, polymers and other fine chemicals. Besides the use of conventional Ullmann reaction, a number of mild Ullmann-type *N*-arylations has been reported in the recent years. As a prelude to this section, literature reports have been discussed. Over the last decade, Chan and coworkers have reported an important alternative, where aryl boronic acids are used as arylating agents instead of aryl halides. Their methods are, however, associated with some disadvantages. The present work described in this section (**Chapter-I, Section-A**), is an experimentally simple microwave assisted solvent-free *N*-arylation of primary amines with sodium tetraphenylborate or arylboronic acids, promoted by inexpensive cupric acetate, on the surface of KF-alumina. The reaction is selective for mono-*N*-arylation and a variety of functional groups are tolerated in the process (Scheme 1). This work has been published in *Synth. Commun.* **2004**, *34*(12), 2177.

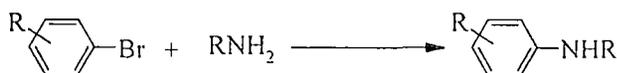
Scheme 1



$\text{R}^1 = \text{Alkyl or Aryl}$

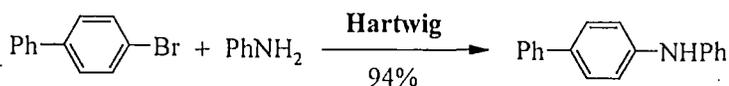
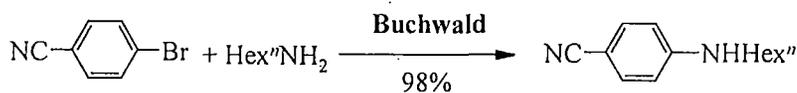
Chapter-I, Section-B deals with **palladium-catalyzed C-N coupling reactions** between aryl bromides and amines in presence of KF-alumina as the base. During the last decade, Buchwald and Hartwig reported independently that aryl halides could be aminated using primary and secondary amines using palladium catalyst, preferably a bis-phosphine ligand and a base, sodium *t*-butoxide (Scheme 2).

Scheme 2



Buchwald
cat. $\text{Pd}_2(\text{dba})_3$
BINAP
 $\text{NaO}i\text{Bu}'$
toluene, 80 °C

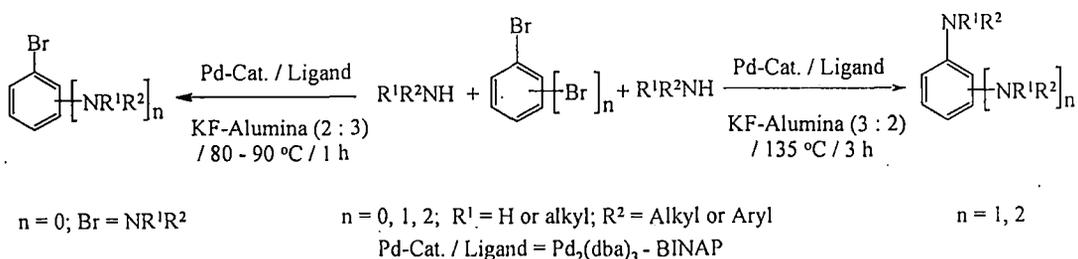
Hartwig
cat. $(\text{dppf})\text{PdCl}_2$
dppf
 $\text{NaO}i\text{Bu}'$
THF, 100 °C



The introduction of **Section-B** describes various developments and modifications of the Buchwald-Hartwig amination process. The present work includes an efficient palladium-catalyzed amination including polyaminations of aromatic bromides mediated on a surface of KF-alumina. The solvent-free one-pot protocol avoids the

use of a strong base sodium *tert*-butoxide demonstrating tolerance with base-sensitive functional group, proceeds with no concomitant reductive debromination and provides access to selective amination while applying to polyhaloaromatics (Scheme 3). A preliminary account of this result has been accepted for publication in *Synlett* 2005.

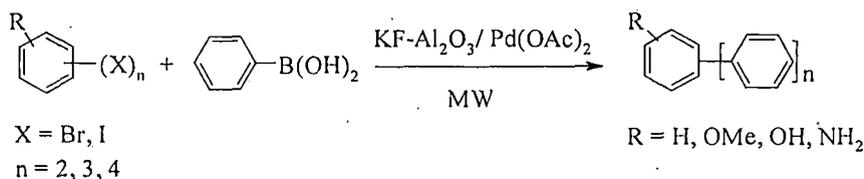
Scheme 3



Chapter-II describes a methodology of **KF-alumina mediated palladium-catalyzed C-C coupling reaction and synthesis of Polyaryls**. Polyaryls find several applications as liquid crystals, laser-dye and conducting polymers. For example, the (*o*-, *m*-, *p*-isomers) are used industrially as heat storage and transfer agents and as textile dye carriers whilst the *p*-isomer has found application as a laser dye. 9,10-Diphelylanthracene is used as a fluorescer in a peroxyoxalate chemiluminescence system.

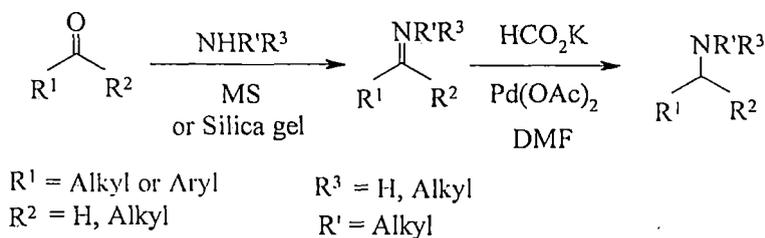
Most of the classical methods are often complicated by harsh reaction conditions, lack of selectivity and generality, or the requirement of expensive reagents. Moreover, many of the methods are not being recognized from the viewpoint of green chemistry. Recent literature reports confirm that palladium-catalyzed Suzuki coupling reactions of aryl halides with aryl boronic acids (or esters) have become convenient and widely used synthetic methods for regioselective aryl-aryl bond formation. We envisaged that a multi-Suzuki coupling of *di*-, *tri*- or *tetra*-haloaromatics with aryl boronic acids could lead to terphenyls and higher homologues in a one-pot reaction (Scheme 4). The results have been published in *Tetrahedron Lett.* 2003, 44, 3817.

Scheme 4



Chapter-III: Section-A deals with the development of a simple protocol for direct reductive amination of aldehydes and ketones using potassium formate and catalytic palladium acetate. The combination of HCOOK and catalytic Pd(OAc)₂ serves as a mild, safe reductant system. In this part, we described our results for direct reductive amination, which constitute a mild, safe and efficient one-pot reductant system for conversion of various aldehydes and ketones, including conjugated ones, to *N*-alkyl/*N*-aryl secondary or tertiary amines (Scheme 5). An account of these findings has been published in *Synlett* **2003**, *4*, 555.

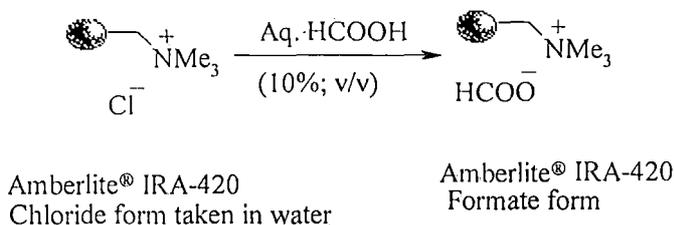
Scheme 5



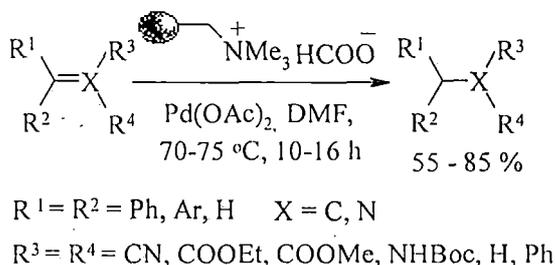
Section-B delineates studies on polymer-supported formate (PSF) based stable H-donors in solid phase Catalytic Transfer Hydrogenation (CTH) reactions. The PSF was prepared by washing Amberlite resin (IRA-420, chloride form) with 10% aq. HCOOH followed by repeated washings with water (Scheme 6). The use of Hydrogen donor has some advantages over the use of molecular hydrogen since it avoid the risks and the constraints associated with hydrogen gas as well as the necessity for pressure vessels and other equipment. A method for CTH of C-C and C-N double bonds with the aid of polymer supported formate (PSF) as the hydrogen donor and palladium

acetate as the catalyst is described in this section (Scheme 7). A preliminary account of this result has been published in *Tetrahedron Lett.* **2003**, *44*, 8931.

Scheme 6



Scheme 7

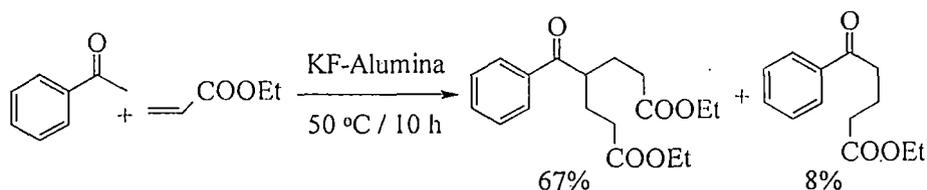


Chapter-IV: Section-A, depicts **KF-alumina mediated selective double Michael additions of aryl methyl ketones: a facile entry to the synthesis of functionalized pimelate esters and derivatives.** Organic reactions on insoluble inorganic supports have stimulated considerable interest among synthetic chemists in the recent years. Advantages frequently claimed in favor of using supported reagents compared with their homogeneous counterparts are ease of set-up and work-up; mild experimental conditions, rapid reactions, and gains in yield and or selectivity.

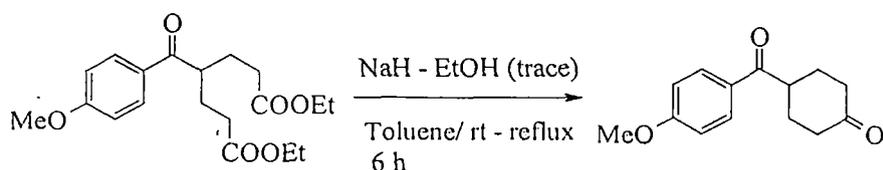
An efficient one-pot procedure for the double Michael reactions promoted on a surface of KF-alumina leading to the synthesis of a host of functionalized pimelate esters are described in this section (Scheme 8). The resulting pimelate esters can be

subjected to Dieckmann cyclization to obtain functionalized cyclohexanone (Scheme 9). The results have been published in *Synlett* 2004, 12, 2224.

Scheme 8



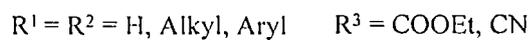
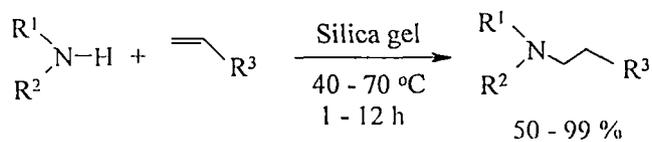
Scheme 9



This section (**Section-B**), covers a study of aza-Michael reaction promoted on solid silica surface. Several groups have reported sub-stoichiometric use of some Lewis acids such as $\text{Yb}(\text{OTf})_3$, $\text{Bi}(\text{OTf})_3$, $\text{Bi}(\text{NO}_3)_3$, hydrated $\text{CeCl}_3\text{-NaI}$ supported on silica gel or clay. Despite their remarkable success, however, the literature reveals that these catalysts are very substrate-selective. Solvent-free and catalyst-free conjugate addition of amines to electron-deficient alkenes has also been reported with several limitations.

Therefore, the need for the development of more general and environmentally benign methods remains. As part of our continuing effort to develop novel methods of surface-mediated solvent-free organic reactions, an efficient and practical procedure for conjugate addition of amines to α,β -unsaturated esters and derivatives promoted on a surface of silica gel has been developed and described in this section (Scheme 8).

Scheme 10



The addition reaction has been successful with aliphatic and aromatic amines yielding β -amino esters or nitriles in good to excellent yields. An account of this protocol has been published in *Synlett* **2004**, *14*, 2630.