

Diazonium Coupling Reaction

Diazonium Coupling: A Comprehensive Q&A

Introduction: What is Diazonium Coupling and Why Should We Care? Q: What is the diazonium coupling reaction? A: Diazonium coupling is an important organic reaction where a diazonium ion ($\text{ArN}\ddot{\text{N}}\text{+}$), a highly reactive electrophile, reacts with an electron-rich aromatic compound (a coupling component) to form an azo compound (Ar-N=N-Ar'). This reaction is crucial in the synthesis of a vast array of azo dyes, pigments, and pharmaceuticals. Its relevance stems from the ability to introduce a diverse range of functional groups onto aromatic rings, altering their properties significantly.

Section 1: The Diazonium Ion – The Key Player

Q: How are diazonium salts prepared? A: Diazonium salts are typically synthesized via diazotization, a reaction where a primary aromatic amine (ArNH_2) reacts with nitrous acid (HNO_2) at low temperatures (0–5°C). Nitrous acid is often generated in situ by reacting sodium nitrite (NaNO_2) with a strong acid like hydrochloric acid (HCl) or sulfuric acid (H_2SO_4). The reaction proceeds through the formation of a nitrosamine intermediate, which then tautomerizes and loses water to form the diazonium ion. The overall reaction is: $\text{ArNH}_2 + \text{HNO}_2 + \text{HCl} \rightarrow \text{ArN}\ddot{\text{N}}\text{Cl} + 2\text{H}_2\text{O}$

Q: What makes diazonium ions so reactive? A: The diazonium ion's reactivity arises from the positive charge on the nitrogen atom and the electron-withdrawing nature of the diazonium group. This makes the nitrogen atom highly electrophilic, readily attacking electron-rich aromatic rings. The nitrogen–nitrogen triple bond is also relatively weak, contributing to its reactivity.

Section 2: Coupling Components – The Electron-Rich Partners

Q: What types of compounds can act as coupling components? A: Effective coupling components are aromatic compounds with electron-donating groups (EDGs) such as hydroxyl ($-\text{OH}$), amino ($-\text{NH}_2$), or alkoxy ($-\text{OR}$) groups. These EDGs increase the electron density in the aromatic ring, making it more susceptible to electrophilic attack by the diazonium ion. Examples include phenols, naphthols, anilines, and N,N -dialkylanilines. The position of the EDG on the aromatic ring influences the regioselectivity of the coupling reaction.

Q: How does the structure of the coupling component influence the reaction? A: The position of the EDG(s) dictates where the diazonium ion attacks. For example, phenols typically couple at the para position, while if the para position is already occupied, coupling occurs at the ortho position. The presence of multiple EDGs can enhance reactivity and influence the shade of the resulting azo dye. Steric hindrance can also play a role, affecting the rate and regioselectivity of the coupling.

Section 3: Reaction Conditions and Mechanism

Q: What are the typical reaction conditions for diazonium coupling? A: Diazonium coupling is typically carried out in weakly acidic or neutral conditions (pH 4–7). Strongly acidic conditions can protonate the coupling component, reducing its nucleophilicity. Strongly alkaline conditions can lead to the decomposition of the diazonium ion. The reaction

is usually performed at low temperatures (0–10°C) to prevent decomposition of the diazonium salt and to control the reaction rate. Q: What is the mechanism of the diazonium coupling reaction? A: The reaction proceeds through an electrophilic aromatic substitution (EAS) mechanism. The electrophilic diazonium ion attacks the electron-rich aromatic ring of the coupling component, forming a sigma complex. This intermediate then loses a proton to regenerate aromaticity, resulting in the formation of the azo compound. Section 4: Applications and Examples Q: What are some real-world applications of diazonium coupling? A: Diazonium coupling is widely used in the production of azo dyes, which are used to color fabrics, leather, paper, and food. Many commercially important dyes, like Methyl Orange and Congo Red, are synthesized using this reaction. Beyond dyes, it finds applications in the synthesis of pharmaceuticals, pigments for paints and inks, and in the preparation of polymeric materials. Example: Synthesis of Methyl Orange The coupling of diazotized sulfanilic acid with N,N-dimethylaniline yields Methyl Orange, a common acid-base indicator. Section 5: Conclusion and FAQs Takeaway: Diazonium coupling is a versatile and widely employed reaction in organic chemistry, particularly in the synthesis of azo compounds with applications spanning diverse fields. Understanding the factors influencing the reaction, such as the structure of the diazonium ion and coupling component, and reaction conditions is crucial for successful synthesis and application. FAQs: 1. Q: What are some common side reactions in diazonium coupling? A: Side reactions include decomposition of the diazonium salt, formation of diazo oxides, and unwanted coupling at multiple positions on the coupling component. Careful control of pH and temperature is crucial to minimize these side reactions. 2. Q: How can I purify the azo compound obtained after coupling? A: Purification techniques depend on the specific azo compound. Common methods include recrystallization, column chromatography, and extraction. 3. Q: What are the safety precautions when working with diazonium salts? A: Diazonium salts can be explosive, especially in the dry state. They should be handled with caution, and large quantities should be avoided. Appropriate personal protective equipment (PPE) should be worn. 4. Q: Can diazonium coupling be used with aliphatic amines? A: While diazonium coupling primarily works with aromatic amines, it can be adapted for some aliphatic amines under specific conditions, often yielding less stable products. 5. Q: How can I predict the color of the azo dye produced? A: The color of the azo dye is influenced by several factors, including the structure of the diazonium ion and the coupling component, the number and position of substituents on the aromatic rings, and the extent of conjugation in the azo compound. While precise prediction is complex, general trends exist and are documented in dye chemistry literature. The presence of extended conjugation usually results in deeper colours.

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in 1972 a very powerful catalytic cycle for carbon carbon bond formation was first discovered by the coupling reaction of grignard reagents at the sp carbon over the past 30 years the protocol has been substantially improved and expanded to other coupling reactions of li b n o al si p s cu mn zn in sn and hg compounds these reactions provided an indispensable and simple methodology for preparative organic chemists due to the simplicity and reliability in the carbon carbon carbon heteroatom and carbon metalloid bond formations as well as high efficiency of the catalytic process the reactions have been widely employed by organic chemists in various fields application of the protocol ranges from various syntheses of complex natural products to the preparation of biologically relevant molecules including drugs and of sup molecules and to functional materials the reactions on solid surfaces allow robot synthesis and combinatorial synthesis now many organic chemists do not hesitate to use transition metal complexes for the transformation of organic molecules indeed innumerable organic syntheses have been realized by the catalyzed reactions of transition metal complexes that are not achievable by traditional synthetic methods among these the metal catalyzed cross coupling reactions have undoubtedly contributed greatly to the development of such a new area of metal catalyzed organic syntheses an excellent monograph for the cross coupling reactions and other metal catalyzed c c bond forming reactions recently appeared in metal catalyzed cross coupling reactions wiley vch 1998

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carbon carbon bond forming reactions are arguably the most important processes in chemistry as they represent key steps in the building of complex molecules from simple precursors among these reactions metal catalyzed cross coupling reactions are extensively employed in a wide range of areas of preparative organic chemistry ranging from the synthesis of complex natural products to supramolecular chemistry and materials science in this work a dozen internationally renowned experts and leaders in the field bring the reader up to date by documenting and critically analyzing current developments and uses of metal catalyzed cross coupling reactions a particularly attractive and useful feature that enhances the practical value of this monograph is the inclusion of key synthetic protocols in experimental format chosen for broad utility and application this practice oriented book can offer the practitioner short cuts to ensure they remain up to date with the latest developments

cross coupling reactions an overview opens with an overview of the fundamentals and applications of the young and fast developing area of transition metal catalyzed mediated oxidative dehydrogenative c h c h coupling reactions between two hetero arenes continuing the authors highlight the recent advances regarding the ligand supported transition metal catalyzed domino cascade or one pot syntheses of various heterocycles involving cross coupling reactions the recent advances in cu catalyzed tandem reactions for heterocycle synthesis are also addressed cu metal chemistry has garnered attention as a potential alternative to precious transition metals being cheaper more sustainable and more easily available a comprehensive account of research on green chemical routes is provided involving various palladium metal based catalysts utilized in facilitating cross coupling reaction in aqueous media reported decarboxylative cross coupling reactions are discussed

along with suitable examples focusing on their mechanism of action

this book is a comprehensive text covering the research and development trends in the booming field of transition metal catalyzed oxidative cross coupling reactions oxidative cross coupling reaction is a new method to forming chemical bonds besides the traditional cross coupling reactions this book provides the answers to how this coupling reaction occurs and what its advantages are the palladium copper and iron catalyzed oxidative cross coupling reactions as the main focuses of interest are described in detail the oxidative cross coupling reactions catalyzed by other metals and transition metal free oxidative coupling reactions are also introduced this book provides a useful reference source for researchers and graduates in the field of transition metal catalyzed coupling reactions it is also valuable to researchers working in pharmaceutical companies fine organic chemical companies and etc

the first handbook on this emerging field provides a comprehensive overview of transition metal catalyzed coupling reactions in the presence of an oxidant following an introduction to the general concept and mechanism of this reaction class the team of authors presents chapters on c c cross coupling reactions using organometallic partners c heteroatom bond forming reactions via oxidative couplings and c h couplings via c h activation the text also covers such groundbreaking topics as recent achievements in the fields of c c and c x bond formation reactions as well as c h activation involving oxidative couplings with its novel and concise approach towards important building blocks in organic chemistry and its focus on synthetic applications this handbook is of great interest to all synthetic chemists in academia and industry alike

the long awaited handbook for all synthetic chemists working on coupling reactions compiling all major catalyst components in use in the area consists of a compilation of articles taken from the eros database with the inclusion of about 20 newly commissioned catalysts pre catalysts ligands that have made an impact in this area of synthetic organic chemistry includes catalyst systems used in heck kumada tamao corriu suzuki miyaura hiyama hatanaka negishi migita kosugi stille buchwald hartwig and tsuji trost coupling reactions

this book is a printed edition of the special issue suzuki miyaura cross coupling reaction and potential applications that was published in catalysts

this handbook and ready reference brings together all significant issues of practical importance in selected topics discussing recent significant achievements for interested readers in one single volume while covering homogeneous and heterogeneous catalysis the text is unique in focusing on such important aspects as using different reaction media microwave techniques or catalyst recycling it also provides a comprehensive treatment of key issues of modern day coupling reactions having emerged and matured in recent years and emphasizes those topics that show potential for future development such as continuous flow systems water as a reaction medium and catalyst immobilization among others with its inclusion of large scale applications in the pharmaceutical industry this will equally be of

great interest to industrial chemists from the contents palladium catalyzed cross coupling reactions a general introduction high turnover heterogeneous palladium catalysts in coupling reactions the case of pd loaded on dealuminated y zeolites palladium catalyzed coupling reactions with magnetically separable nanocatalysts the use of ordered porous solids as support materials in palladium catalyzed cross coupling reactions coupling reactions induced by polymer supported catalysts coupling reactions in ionic liquids cross coupling reactions in aqueous media microwave assisted synthesis in c c and c heteroatom coupling reactions catalyst recycling in palladium catalyzed carbon carbon coupling reactions nature of the true catalytic species in carbon carbon coupling reactions with heterogeneous palladium precatalysts coupling reactions in continuous flow systems large scale applications of palladium catalyzed couplings in the pharmaceutical industry

palladium catalysed cross coupling reactions constitute a powerful class of chemical methods for the creation of carbon carbon and carbon heteroatom bonds used in organic synthesis famously recognized by the 2010 nobel prize awarded to richard f heck ei ichi negishi and akira suzuki for palladium catalysed cross couplings in organic synthesis these methods have become ubiquitous in academic and industrial settings alike as applications span from industrial production of pharmaceuticals agrochemicals polymers and dyes to the synthesis of complex natural products new trends in cross coupling provides the reader with the history and basic concepts of cross coupling up to the state of the art in modern coupling reactions from both technology and applied perspectives a wide breadth of topics including selecting prominent ligand types advances in pd phosphine precatalysts and pd n heterocyclic carbene complexes new reactions such as carboiodination implementation of new technologies such as continuous flow and advanced metal detection methods greener approaches to cross coupling as well as large scale applications in the syntheses of pharmaceutical materials are covered edited by thomas j colacot an industrial expert on cross coupling the book contains contributions from academic and industrial world leaders in the field as well as a forewords from professor barry m trost gregory c fu and 2010 nobel laureate in chemistry professor ei ichi negishi new trends in cross coupling serves as a reference guide for both undergraduate and graduate students as well as those who are experts in the area this compilation a must for anyone interested in learning and using newer trends in cross coupling ei ichi negishi 2010 nobel laureate in chemistry i am very pleased to see such a book concerning cross coupling reactions published professor akira suzuki 2010 nobel laureate in chemistry this book is invaluable to anyone involved in synthesis of organic compounds for any purpose professor barry trost stanford university

the series topics in current chemistry collections presents critical reviews from the journal topics in current chemistry organized in topical volumes the scope of coverage is all areas of chemical science including the interfaces with related disciplines such as biology medicine and materials science the goal of each thematic volume is to give the non specialist reader whether in academia or industry a comprehensive insight into an area where new research is emerging which is of interest to a larger scientific audience each review within the volume critically surveys one aspect of that topic and places it within the context of the volume as a

whole the most significant developments of the last 5 to 10 years are presented using selected examples to illustrate the principles discussed the coverage is not intended to be an exhaustive summary of the field or include large quantities of data but should rather be conceptual concentrating on the methodological thinking that will allow the non specialist reader to understand the information presented contributions also offer an outlook on potential future developments in the field

providing comprehensive insight into the use of copper in cross coupling reactions copper mediated cross coupling reactions provides a complete up to date collection of the available reactions and catalytic systems for the formation of carbon heteroatom and carbon carbon bonds this essential reference covers a broad scope of copper mediated reactions their variations key advances improvements and an array of academic and industrial applications that have revolutionized the field of organic synthesis the text also discusses the mechanism of these transformations the use of copper as cost efficient alternative to palladium as well as recently developed methods for conducting copper mediated reactions with supported catalysts

the whole field of ligand coupling has only emerged in the last decade as a basis for new synthetic transformations as professor finet shows in this comprehensive survey the recent clarification of reaction mechanisms of ligand coupling process around heteroatom centres now provides an understanding of these reactions which are certain to permit their application in organic synthesis thereby achieving transformations which are quite difficult to achieve by other methods this book provides in a thorough and scholarly way a balanced coverage of the whole field

in this special issue recent advances in cross coupling reactions are presented in the form of original research articles reviews and short communications these contributions cover different topics in this area including novel coupling reactions reaction conditions synthetic alternatives metal ligands and applications for new pharmaceutical compounds and organic materials in particular the reviews deal with methodologies such as the synthesis of diarylketones through palladium catalysis and the most relevant examples of suzuki miyaura and buchwald hartwig coupling reactions in the synthesis of bioactive compounds the synthetic utility of cross coupling reactions for the synthesis of medium size rings and the utility of stille and suzuki coupling reactions for the synthesis of new molecular machines based on sterically hindered anthracenyl trypticenyl units are also summarized the original research articles present the synthesis of 2 alkynylpyrrols by inverse sonogashira coupling and the synthesis of indoles under oxidative dearomative cross dehydrogenative conditions the efficient combination of iridium catalyzed c h borylation of aryl halides with the sonogashira coupling and a sequential iridium catalyzed borylation of nh free pyrroles followed by a suzuki miyaura reaction are included the synthesis of aryl propionic acids a common structural motif in medicinal chemistry and the synthesis of new organic dyes are also covered

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this three volume book is the follow up handbook to the bestselling volume metal catalyzed cross coupling reactions the definitive reference in the field in line with the enormous developments in this area this is not a new edition but rather a new book in three volumes with over 50 more content this new content includes c h activation shifting the focus away from typical cross coupling reactions while those topics and chapters found in de meijere diederich s book have been updated and expanded with its highly experienced editor team and the list of authors reading like an international who s who in the field this work will be of great interest to every synthetic chemist working in academia and industry

applied cross coupling reactions provides students and teachers of advanced organic chemistry with an overview of the history mechanisms and applications of cross coupling reactions since the discovery of the transition metal catalyzed cross coupling reactions in 1972 numerous synthetic uses and industrial applications have been developed the mechanistic studies of the cross coupling reactions have disclosed that three fundamental reactions oxidative addition transmetalation and reductive elimination are involved in a catalytic cycle cross coupling reactions have allowed us to produce a variety of compounds for industrial purposes such as natural products pharmaceuticals liquid crystals and conjugate polymers for use in electronic devices indeed the nobel prize for chemistry in 2010 was awarded for work on cross coupling reactions in this book the recent trends in cross coupling reactions are also introduced from the point of view of synthesis design and catalytic activities of transition metal catalysts

find out how theoretical calculations are used to determine elucidate and propose mechanisms for pd catalyzed c c cross coupling reactions in max garcia melchor s outstanding thesis garcia melchor investigates one of the most significant and useful types of reactions in modern organic synthesis the pd cross coupling reaction due to its versatility broad scope and selectivity under mild conditions this type of reaction can now be applied in fields as diverse as the agrochemical and pharmaceutical industry garcia melchor studies the reaction intermediates and transition states involved in the negishi the copper free sonogashira and the asymmetric version of suzuki miyaura coupling he also characterizes and provides a detailed picture of the associated reaction mechanisms the author has won numerous prizes for this work which has led to over eight publications in internationally renowned journals

transition metal catalyzed coupling reactions have a rich history that led to the awarding of the 2010 nobel prize in chemistry to professors suzuki heck and negishi for their pioneering contributions to the field the coming of age of this active area of research is showcased in

this book through case studies in which process chemists from the pharmaceutical industry share their personal experiences developing their own transition metal catalyzed couplings for the large scale manufacture of active pharmaceutical ingredients authors from pfizer merck boehringer ingelheim novartis amgen gsk astrazeneca and other companies describe the evolution of robust coupling processes from inception through early and late development including commercial routes where applicable this book covers a wide range of coupling transformations while capturing the lessons learned from each process every case study details the optimization of at least one transition metal catalyzed coupling while elaborating on issues such as design of experiments scalability and throughput product purification process safety and waste management the important issue of metal removal and the different technologies available to accomplish this goal are also addressed finally a section covers novel technologies for cross coupling with high potential for future applications on a large scale such as microwave and flow chemistry as well as green cross couplings performed in water with forewords by stephen I buchwald massachusetts institute of technology trevor laird editor of organic process research and development and neal g anderson anderson s process solutions llc

kurti and czako have produced an indispensable tool for specialists and non specialists in organic chemistry this innovative reference work includes 250 organic reactions and their strategic use in the synthesis of complex natural and unnatural products reactions are thoroughly discussed in a convenient two page layout using full color its comprehensive coverage superb organization quality of presentation and wealth of references make this a necessity for every organic chemist the first reference work on named reactions to present colored schemes for easier understanding 250 frequently used named reactions are presented in a convenient two page layout with numerous examples an opening list of abbreviations includes both structures and chemical names contains more than 10 000 references grouped by seminal papers reviews modifications and theoretical works appendices list reactions in order of discovery group by contemporary usage and provide additional study tools extensive index quickly locates information using words found in text and drawings

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Introduction

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