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Synthesis of Bis-Hydrazine Using Heterogeneous Catalysis †

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Abstract: Hydrazine derivatives are known as a group of organic compounds containing C=N-N=C functional groups. This π-conjugated system enables electronic excitation in the visible and near-ultraviolet regions. This is of particular interest for many applications, such as corrosion inhibition dye-sensitized solar cells (DSSC), organogels, and fluorescent probes for analytical testing. In addition, many hydrazine derivatives show notable biological and therapeutic activities such as the treatment of tuberculosis, Parkinson's disease, and hypertension. Schiff bases form a remarkable class of ligands because of their unique properties, such as stability under different conditions, diversity of donor sites, the flexibility of synthesis, and formation of ranges in various coordination geometries in a wide range of complexes. Their complexes have received widespread attention due to their wide range of applications, such as catalysis, electrochemistry, biological sciences, optics, guest chemistry, and molecular recognition. Therefore, from theoretical and practical points of view, the synthesis of hydrazine derivatives is an important issue. In the present study, we describe a new, efficient, and environmentally benign synthetic method for the formation of hydrazine derivatives with heterogeneous catalysis starting from ketones.

Keywords: heterogeneous catalysis; Bis-hydrazine; azines; ketazines

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1. Introduction

Heterogeneous catalysis is one of the most important industrial processes in chemical manufacturing today. It is based on surface reactions, which require the adsorption of at least one reactant on the catalyst surface [1]. In recent years, the use of heterogeneous catalysts in organic synthesis has raised great interest due to its inherent advantages such as easy post-processing, reusability, and low cost [2]. As long as the active sites are not deactivated, the heterogeneous catalyst can be easily distinguished from the reaction mixture by simple filtration and reused in subsequent reactions. Heterogeneous catalysis also helps to minimize the waste generated from post-reaction processing and promotes the development of green chemical processes [3].

The azines (2,3-diaza-1,3-butadiene) of the formula $R_1R_2C{=}N{-}N{=}CR_1R_2$ are a class of functional compounds. They are sometimes called NN-linked diimines (C=NN=C) [4]. They have received increasing attention due to their chemical properties, and they facilitate the construction of medically important heterocyclic compounds involving cycloaddition reactions [5–8].

In addition, such compounds have been used to design covalent organic frameworks (COF) [9] and as building blocks of supramolecular chemistry [10,11]. Due to their interesting physical properties, azines have been used as conductive materials [12,13], ion-selective optical sensors [14,15], and nonlinear optical (NLO) materials [16,17]. In addition, azines have potential biological properties (Figure 1), such as antibacterial [18], antihypertensive [19], antifungal [20], antibacterial [21], and anticancer [22] activities. They are useful candidates for drug development in the pharmacology industry.

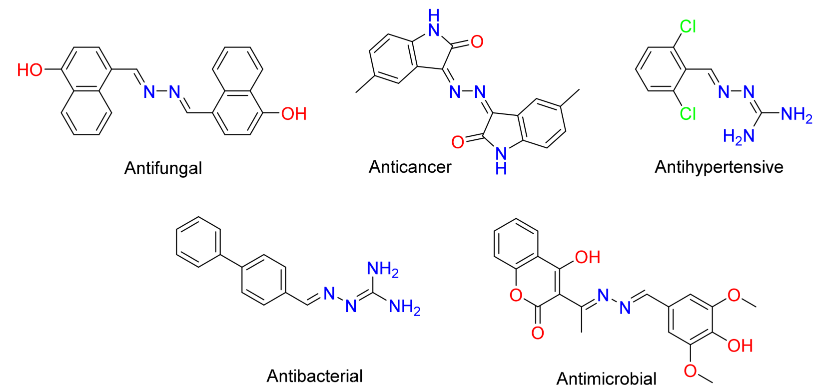
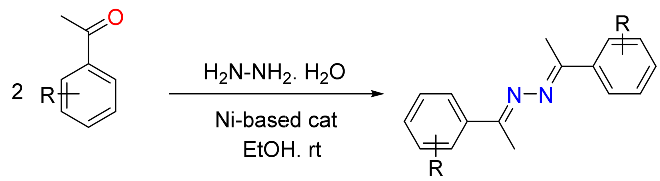


Figure 1. Biologically active azines.

These compounds are usually synthesized by condensation of hydrazine and aldehyde/ketone [23]. With the latest developments in chemistry, several other methods of synthesizing azines have also been reported [24]. In recent years, the transition-metal-catalyzed, single-step scheme for the synthesis of azine has gained much attention [25]. In the present study, a nickel-based heterogeneous catalyst was utilized for the synthesis of ketazine derivatives with a new, efficient, and environmentally benign synthetic method in a short time at room temperature, resulting in high yields.

2. General Experimental Procedure

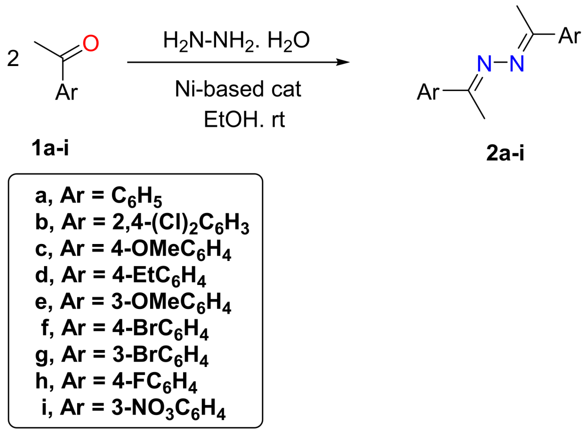
A mixture of acetophenone (2.08 mmol) in ethanol (15 mL) was stirred with hydrazine hydrate (1 mmol), and then a Ni-based heterogeneous catalyst was added to the mixture with a small amount. The reaction mixture was stirred at room temperature until solidified. The precipitated product was filtered, washed with water, dried, and then crystallized from ethanol to give (76–89% yield) of ketazines in less than 3 h (Scheme 1).



Scheme 1. General synthesis pathway of ketazines using Ni-based heterogeneous catalyst.

3. Results and Discussion

After optimization of the reaction conditions using different solvents in different temperatures, it was observed that the condensation of hydrazine hydrate with various acetophenone derivatives **1a-i** proceeded smoothly in the presence of ethanol and nickel-based heterogeneous catalyst at room temperature, resulting in the formation of ketazines **2a-i** with good-to-excellent yields in less than three hours (Scheme 2).



Scheme 2. Synthesis of ketazines using Ni-based heterogeneous catalyst.

4. Conclusions

In summary, in this study, we reported the synthesis of ketazines (Bis-hydrazine derivatives) in the presence of a nickel-based heterogeneous catalyst using hydrazine hydrate and various acetophenone derivatives. The reaction was carried out with low catalyst loadings and short reaction times and, therefore, provides an economic and environmentally friendly approach.

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