RECYCLIZATION OF 1,3,4-OXADIAZoles
AND BIS-1,3,4-OXADIAZoles INTO
1,2,4-TRIAZOLE DERIVATIVES. SYNTHESIS OF
5-UNSUBSTITUTED 1,2,4-TRIAZoles

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Efficient methods have been developed for obtaining precursors of stable carbenes, viz. 5-unsubstituted 3,4-diaryl-1,2,4-triazoles and 3,3'- or 4,4'-bridge linked bis-1,2,4-triazoles, by the recyclization of 5-unsubstituted 1,3,4-oxadiazoles or p-phenylenebis-1,3,4-oxadiazole with anilines or aromatic diamines in the presence of trifluoroacetic acid or with aniline hydrochlorides in pyridine.

Keywords: 3,4-diaryl-1,2,4-triazoles, precursors of stable carbenes, 1,3,4-oxadiazoles, 3,3'- and 4,4'-bridge linked bis-1,2,4-triazoles, recyclization reaction.

One of the most important methods of obtaining the 1,2,4-triazole system is based on recyclization reactions of 1,3,4-oxadiazoles under the action of amines and hydrazines [1, 2]. These conversions are used for obtaining both monotriazoles and polytriazoles [2]. Recyclization in a series of individual aliphatic derivatives, particularly 2,5-dimethyl-1,3,4-oxadiazole, with amines (taking place at 110°C) has been known for a fairly long time [3]. Recyclization of aromatic derivatives, such as 2,5-diaryl-1,3,4-oxadiazoles, also gives triazoles, but are effected under more forcing conditions (150-200°C) [4]. However the latter process, according to our data, is accompanied by the formation of significant quantities of colored material which hinders the isolation of individual substances. In [5, 6] the recyclization is described of 2,5-dialkyl-1,3,4-oxadiazoles with hydrazines leading to derivatives of 4-amino-1,2,4-triazoles. It proceeds well with unsubstituted hydrazine even at room temperature, with monoalkylhydrazines with significantly more difficulty, on boiling in an excess of reactant, and leads to a low yield of 4-alkylamino-1,2,4-triazoles.

Among the numerous variants of recyclization, the reaction of 5-unsubstituted oxadiazoles has not been studied, and might give 5-unsubstituted 1,2,4-triazoles, important precursors in the synthesis of stable carbenes of the 1,2,4-triazole series (their salts act as precursors). The reaction was not used for the synthesis of bistriazole systems, including those unsubstituted in positions 3 or 5.

In connection with the development of the chemistry of stable carbenes it seemed of interest to synthesize 3-unsubstituted triazoles and the triazolium system. A method of obtaining triazolium salts is known, which consists of the conversion of amides with phosphorus oxychloride into the corresponding imidoyl chlorides, reaction of the latter with 1-substituted formhydrazides and cyclization of the condensation products...
with acetic anhydride [7]. But in this synthesis good yields (58-84%) of the desired salts were achieved in only three cases, in the others, particularly in the synthesis of bisazolium systems, extremely moderate or low yields of salts (11-41%) were obtained. Data are not presented in this paper on the possibility of synthesizing neutral triazoles and conjugated bistriazole systems.

Our problem is the development of a means of recyclizing 1,3,4-oxadiazoles which should be useful for obtaining triazole precursors of stable carbenes, 5-unsubstituted 1,2,4-triazoles, particularly conjugated 1,2,4-triazoles, and would not lead to the formation of colored material.

To solve this problem initially the effect of acid additives on the yield of triazoles was studied in the example of the reaction of model compound 2-phenyl-1,3,4-oxadiazole (1a) with aniline 2a.

\[
\begin{array}{ccc}
1a, b & \xrightarrow{R^1 NH_3, CF_3COOH} & 3a-f \\
1a R = H, b R = Br; 3a-d R = H; e,f R = Br; 2, 3a R^1 = Ph, b R^1 = C_6H_5Br-p, \\
c R^1 = C_6H_5Me-p; d R^1 = \alpha-C_10H_7; 3e R^1 = Ph, f R^1 = C_6H_5Br-p
\end{array}
\]

On carrying out the reaction of oxadiazole 1a with some aniline salts 2a (hydrochloride, hydrobromide) without solvent the process is accompanied by sublimation of the aniline salt, which does not enable a yield of triazole 3a greater than 30-40% to be achieved. The application of high-boiling aromatic solvents such as 1,2,4-triethylbenzene, without acid components makes an increase in the yield of triazole 3a to 50% possible, but as in the melt colored material was obtained. Under the same conditions sublimation was also observed with aniline hydrochloride, as also on carrying out the process in the more polar \(\alpha\)-dichlorobenzene (\(\mu 2.50\) D). We note that the use of high boiling aprotic solvents (DMF, N-methylpyrrolidone) leads to the formation of a significant amount of unidentified byproducts.

In order to prevent sublimation of the reactant in the process of recyclizing compound 1a in aromatic solvents, in place of aniline hydrohalides we used aniline trifluoroacetate, which was prepared \textit{in situ} from aniline and trifluoroacetic acid. Heating the mixture at 190°C in \(\alpha\)-dichlorobenzene gives a high yield (95%) of 3,4-diphenyl-1,2,4-triazole (3a). In this reaction the favorable action on the yield and purity of triazole 3a proves to be both the acid catalyst and the use of \(\alpha\)-dichloro-benzene, as a result of probably, the adequate polarity of the solvent and the azeotropic mode of removing water during the process.

This procedure was used for the synthesis of other derivatives of 3,4-diaryl-1,2,4-triazole 3b-f and also gave mainly good results (Table 1, 52-77% yields). In the majority of cases significant formation of colored contaminants did not occur. However in the case of the synthesis of naphthyltriazole 3d the formation of colored material was observed, probably with the participation of the naphthyl group which is very inclined to combination reactions, and leads to a reduction in the yield of triazole to 36%.

It was interesting to extend the method to the preparation of 3,3'- and 4,4'-bridge linked bistriazoles, precursors of triazole biscalbenes. On interacting oxadiazole 1a with \(p\)-phenylenediamine hydrochloride in the presence of 2 equiv. sodium acetate in \(\alpha\)-dichlorobenzene 4,4'-\(p\)-phenylenebis-1,2,4-triazole 4a was obtained in 56% yield. The analogous procedure with \(m\)-phenylenediamine dihydrochloride gave only 24% bistriazole 4b. Carrying out the same recylization process with 1a and \(m\)-phenylenediamine base in the presence of an equivalent amount of trifluoroacetic acid in dichlorobenzene increased the yield of bistriazole 4b to 54%.