

# SYNLETT Spotlight 467

This feature focuses on a reagent chosen by a postgraduate, highlighting the uses and preparation of the reagent in current research

## Mercury(II) Chloride

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Felipe Fantuzzi was born in Rio de Janeiro, Brazil in 1987. He received his B.Sc. (2011) and M.Sc. (2013) in chemistry from the Universidade Federal do Rio de Janeiro (UFRJ). He won the Sylvio Canuto Award (2010) and the Presentation Prize at the Brazilian Symposium on Theoretical Chemistry (2013). Currently, he is working towards his Ph.D. in theoretical chemistry at UFRJ under the advisory of Professor Marco A. Chaer Nascimento and the co-advisory of Dr. Thiago M. Cardozo. His research interests focus on the nature of the chemical bond from the quantum interference perspective.

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### Introduction

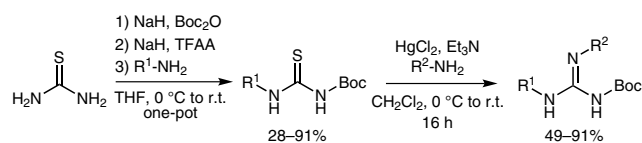
Organomercurials were among the first prepared organometallic compounds, being known since the second half of the 19<sup>th</sup> century.<sup>1,2</sup> Despite their toxicity, mercury compounds are still used in the chemical and petrochemical industries. For instance, the industrial synthesis of vinyl chloride and acetaldehyde from acetylene is carried out using mercury catalysts.<sup>3</sup> Therefore, the study of environmental and health impacts of mercury and organomercurials, as well as the improvement of safety and handling techniques, are of great importance.

Mercury(II) chloride, HgCl<sub>2</sub>, is a commercially available mercury salt, and thus an important mercury(II) source. Besides novel mercuration reactions with organic substrates,<sup>3–7</sup> HgCl<sub>2</sub> has been extensively used in a variety of cyclization reactions, forming both carbocycles and heterocycles.<sup>8–10</sup> Its use as inorganic thiophile has led to the formation of several new products from organosulfur reactants, especially thiocarbonyl compounds.<sup>11–16</sup> Finally, the synthesis of mercury(II) alkynyls, mainly from HgCl<sub>2</sub>, and their use as building blocks for supramolecular structures has been reviewed.<sup>17</sup>

### Abstracts

#### (A) Preparation of Asymmetrical *N,N'*-Disubstituted Guanidines

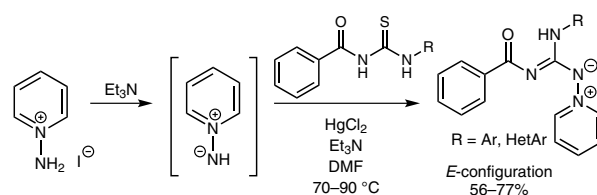
Guanidine is a biologically relevant functional group, because it is found in several natural products and in the amino acid arginine. O'Donovan and Rozas reported a simple route to *N,N'*-asymmetrical disubstituted guanidines from thiourea.<sup>14</sup> The first step is the conversion of thiourea into *N*-Boc-protected *N'*-alkyl/aryl substituted thioureas, which are then treated with an amine in the presence of HgCl<sub>2</sub> and triethylamine.



R<sup>1</sup> = Pr, (CH<sub>2</sub>)<sub>2</sub>OH, (CH<sub>2</sub>)<sub>2</sub>OAc, Ph, 4-Me<sub>2</sub>NC<sub>6</sub>H<sub>4</sub>, 4-EtOC<sub>6</sub>H<sub>4</sub>  
R<sup>2</sup> = Pr, (CH<sub>2</sub>)<sub>2</sub>OH, (CH<sub>2</sub>)<sub>2</sub>OAc, Ph, 4-Me<sub>2</sub>NC<sub>6</sub>H<sub>4</sub>,  
4-EtOC<sub>6</sub>H<sub>4</sub>, 6-(1,2,3,4-tetrahydronaphthalene)

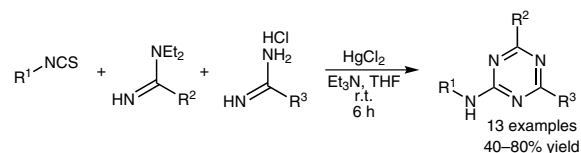
#### (B) Guanylation of *N*-Iminopyridinium Ylides

Cunha et al. reported the synthesis of five pyridinium *N*-benzoylguanidines in moderate to good yields.<sup>11</sup> The *N*-aminopyridinium iodide was subjected to modified guanylation reaction conditions, using HgCl<sub>2</sub> as inorganic thiophile. Among the two possible stereoisomers (due to the C=N bond), only the *E*-configuration was detected in the <sup>1</sup>H NMR spectra. This study represents the first description of an ylide as the nucleophilic partner in the guanylation reaction.



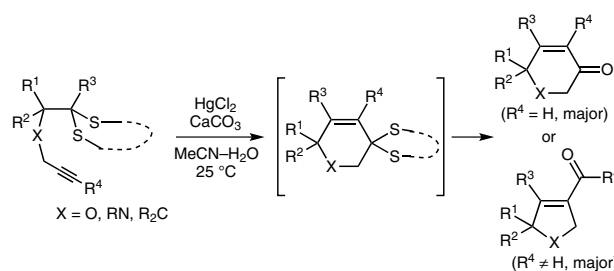
#### (C) Synthesis of Trisubstituted Triazines

Kaila et al. reported a one-pot synthesis of 1,3,5-trisubstituted triazines from isothiocyanates, *N,N*-diethylamidines, and carbamides.<sup>10</sup> An amidinothiurea intermediate is formed from the reaction of the first two materials, which then reacts with the carbamide in the presence of HgCl<sub>2</sub> to generate the desired triazines.



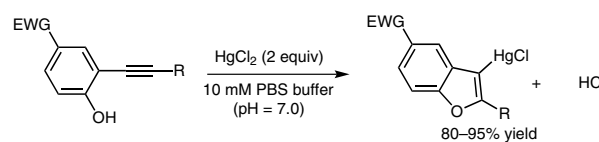
## (D) Carbocyclization of Tethered Alkyndithioacetals

Biswas et al. reported a general route to five- and six-membered carbocyclic and heterocyclic by  $\text{HgCl}_2$ -mediated cyclization of tethered alkyndithioacetals.<sup>9</sup> If the substrate is a terminal alkyne, the formation of six-membered rings is preferential. On the other hand, substitution at the alkyne terminus leads preferentially to five-membered rings. Moreover, it has been shown that the replacement of  $\text{HgCl}_2$  by  $\text{HgI}_2$  interrupts the reaction at the dithioacetal intermediate.

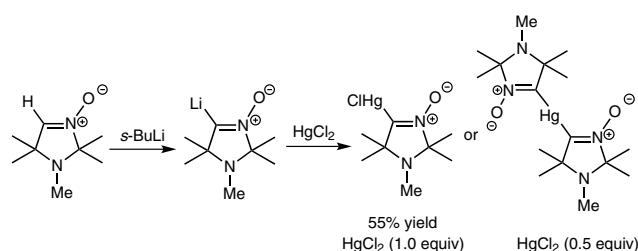


## (E) Intramolecular Cyclization of Ethynyl Phenols

Atta et al. reported a  $\text{Hg(II)}$ -specific intramolecular cyclization reaction of ethynyl phenols in semi-aqueous media at room temperature.<sup>8</sup> The use of a malonitrile derivative as an electron-withdrawing group has led to the development of a  $\text{Hg(II)}$  selective indicator that displays a color change from blue to pale yellow.

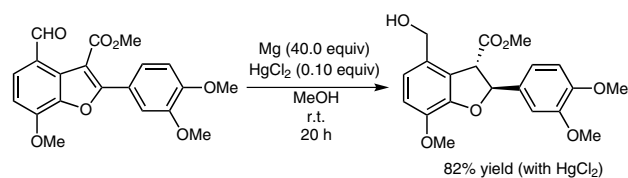
(F) Synthesis of  $\alpha$ -Heteroatom-Substituted Nitrones

The application of nitrones range from biology to polymers and materials chemistry. Voinov and Grigor'ev reported the synthesis of an  $\alpha$ -mercurated cyclic aldonitrone with 55% yield.<sup>4</sup> If only 0.5 equivalents of  $\text{HgCl}_2$  are used in the reaction, a disubstituted mercuric derivative is formed.<sup>5</sup>



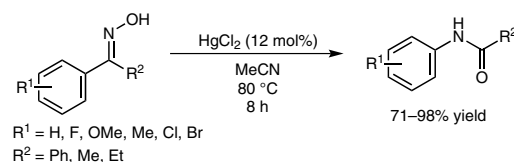
## (G) Reduction of a Benzo[b]furan Ester

Varadaraju and Hwu reported the stereoselective reduction of a benzo[b]furan ester with metallic magnesium, catalytic  $\text{HgCl}_2$ , and methanol as the solvent.<sup>18</sup> The product is a ( $\pm$ )-*trans*-dihydrobenzo[b]furan. The use of  $\text{HgCl}_2$  raised the yield from 30% to 82%. It has been proposed that  $\text{HgCl}_2$  activates the magnesium and thus accelerates the reduction.



## (H) Rearrangement of Ketoximes

The transformation of ketoximes into amides or lactams, known as the Beckmann rearrangement, usually requires harsh conditions which preclude sensitive oximes to react. Ramaligan and Park reported the use of  $\text{HgCl}_2$  in acetonitrile to obtain amides and lactams from a variety of acyclic and cyclic ketoximes with good to excellent yields under essentially neutral conditions.<sup>19</sup>



## References

- Frankland, E. *Phil. Trans. R. Soc.* **1852**, 142, 417.
- Larock, R. C. *Angew. Chem., Int. Ed. Engl.* **1978**, 17, 27.
- Cataldo, F.; Kanazirev, V. *Polyhedron* **2013**, 62, 42.
- Voinov, M. A.; Grigor'ev, I. A. *Tetrahedron Lett.* **2002**, 43, 2445.
- Voinov, M. A.; Shevelev, T. G.; Rybalova, T. V.; Gatilov, Y. V.; Pervukhina, N. V.; Burdukov, A. B.; Grigor'ev, I. A. *Organometallics* **2007**, 26, 1607.
- Liu, L.; Lam, Y.-W.; Wong, W.-Y. *J. Organomet. Chem.* **2006**, 691, 1092.
- Nagapradeep, N.; Verma, S. *Chem. Commun.* **2011**, 47, 1755.
- Atta, A. K.; Kim, S.-B.; Heo, J.; Cho, D.-G. *Org. Lett.* **2013**, 15, 1072.
- Biswas, G.; Ghorai, S.; Bhattacharjya, A. *Org. Lett.* **2006**, 8, 313.
- Kaila, J. C.; Baraiya, A. B.; Pandya, A. N.; Jalani, H. B.; Sudarsanam, V.; Vasu, K. K. *Tetrahedron Lett.* **2010**, 51, 1486.
- Cunha, S.; Rodrigues, M. T. Jr.; da Silva, C. C.; Napolitano, H. B.; Vencato, I.; Lariucci, C. *Tetrahedron* **2005**, 61, 10536.
- Kaila, J. C.; Baraiya, A. B.; Vasu, K. K.; Sudarsanam, V. *Tetrahedron Lett.* **2008**, 49, 7220.
- Kaila, J. C.; Baraiya, A. B.; Pandya, A. N.; Jalani, H. B.; Vasu, K. K.; Sudarsanam, V. *Tetrahedron Lett.* **2009**, 50, 3955.
- O'Donovan, D. H.; Rozas, I. *Tetrahedron Lett.* **2011**, 52, 4117.
- O'Donovan, D. H.; Rozas, I. *Tetrahedron Lett.* **2012**, 53, 4532.
- Insuasty, H.; Insuasty, B.; Castro, E.; Quiroga, J.; Abonia, R. *Tetrahedron Lett.* **2013**, 54, 1722.
- Wong, W.-Y. *Coord. Chem. Rev.* **2007**, 251, 2400.
- Varadaraju, T. G.; Hwu, J. R. *Org. Biomol. Chem.* **2012**, 10, 5456.
- Ramaligan, C.; Park, Y.-T. *J. Org. Chem.* **2007**, 72, 4536.