

SYNLETT Spotlight 413

Phenylselenenyl Zinc Halides

Compiled by Caterina Tidei



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

Caterina Tidei was born in Fermo, Italy, and received her M.Sc. in 2011 in *Chemistry and Technology of Drugs* from the University of Perugia. Currently, she is working towards her PhD under the supervision of Professor Claudio Santi and Francesca Marini at the same institution. Her research interests focus on bioinspired metal-free oxidation, placing emphasis on the development of green procedures.

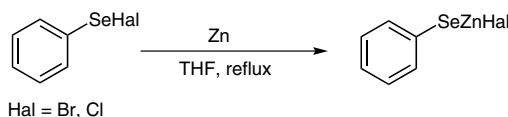
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Introduction

Santi et al.¹ first isolated phenylselenenyl zinc halides as bench-stable selenolates. They are versatile nucleophilic reagents, especially in 'on water' conditions, where they have been used for the synthesis of a large number of organoseleno compounds.² Furthermore, they also show interesting features from a biochemical and pharmaceutical point of view because of the unusual stabilized oxidation state of selenium, the same of the selenium atom present in the catalytic site of some selenoenzymes. On the basis of this, recently a Gpx-like activity for PhSeZnCl has been demonstrated.³

Preparation

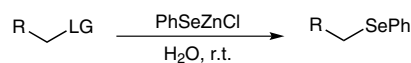
Phenylselenenyl zinc halides can be easily prepared by oxidative insertion of elemental zinc into commercially available phenylselenenyl halides: a stoichiometric amount of zinc powder is added to the substrate in refluxing THF; then the selenolate precipitates from diethyl ether or heptane as an amorphous white solid (mp > 300 °C).



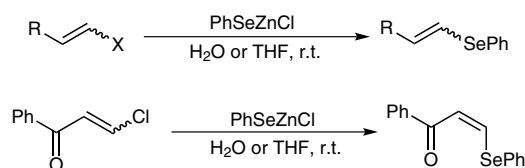
Scheme 1 Preparation of phenylselenenyl zinc halides

Abstracts

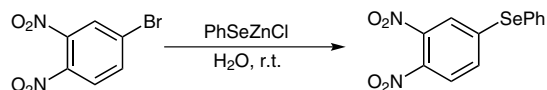
(A) PhSeZnCl has been found to react by an S_N2 mechanism with sp³-carbon atoms containing good leaving groups. The best yields are obtained in a water suspension and with primary halides and tosylates while tertiary carbons do not afford the corresponding substitution products, suggesting a non-radical mechanism.¹



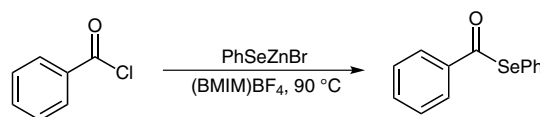
(B) Vinylic halides are able to undergo a nucleophilic substitution with retention of geometry by treatment with PhSeZnCl in THF or in 'on water' conditions; the latter affords the best results. Only in the case of β-halo-α,β-unsaturated ketones a stereoconvergence to the Z-isomer has been observed and it has been attributed, on the basis of DFT calculations, to the coordination of the carbonyl group to zinc.⁴



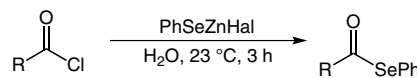
(C) Aromatic substrates only react if they are activated by electron-withdrawing substituents. In the case of 2,4-dinitrobromobenzene the corresponding selenide was obtained in moderate yield (50%).¹ Also in this case the reaction was effected by 'on water' conditions.



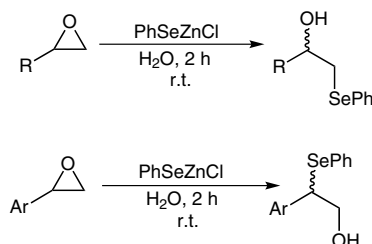
(D) Concerning the substitution at sp^2 -carbon atoms, acyclic substitution can be carried out at 90 °C using PhSeZnBr in the ionic liquid (BMIM)BF₄ in order to obtain selenoesters.⁵ The use of ionic liquid represents an extensive application of this class of reagents in the development of new eco-friendly procedures.



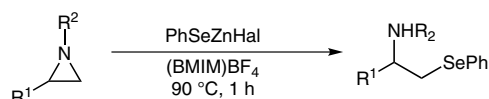
(E) Very recently, Santi et al.⁶ have proposed a greener method to synthesize selenoesters by the reaction of phenylselenenyl zinc halides with acyl chlorides in 'on water' conditions; the products are obtained in moderate to good yield after crystallization from ethyl acetate-hexane and the aqueous medium can be reused.



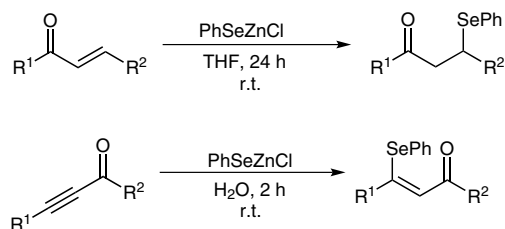
(F) PhSeZnCl has been employed in the ring opening of epoxides, achieving a quantitative yield in a water suspension for a number of alkyl and aryl epoxides. The regioselectivity depends on the electronic and steric properties of the substrate: alkyl epoxides are substituted on the less hindered carbon atom while the aryl ones are attacked on the benzylic position because in this case electronic effects are predominant.¹



(G) β -Seleno amines can be obtained via ring-opening reactions of aziridines promoted by PhSeZnCl under neutral conditions and using (BMIM)BF₄ as the solvent; the yields are moderate but can be improved by the use of PhSeZnBr.⁵



(H) PhSeZnCl promotes Michael-type addition reactions on α,β -unsaturated ketones and conjugated alkynes affording β -seleno carbonyl compounds and vinyl selenides, respectively. In the first case, the reaction proceeds faster in THF while in the second, the 'on water' conditions are preferred. The reaction is stereoconvergent, providing the Z-isomer as the major product.⁷



References

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- (2) Santi, C. *Phenylselenenylzinc halides*, In *Encyclopaedia of Reagents for Organic Synthesis*; Paquette, L. A., Ed.; John Wiley & Sons: New York, DOI: 10.1002/047084289X.m01352.
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- (4) Santoro, S.; Battistelli, B.; Testaferri, L.; Tiecco, M.; Santi, C. *Eur. J. Org. Chem.* **2009**, 4921.
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- (6) Santi, C.; Battistelli, B.; Testaferri, L.; Tiecco, M. *Green Chem.* **2012**, 1277.
- (7) Battistelli, B.; Testaferri, L.; Tiecco, M.; Santi, C. *Eur. J. Org. Chem.* **2011**, 1848.