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Addition of a Sulfur-Stabilized Radical to Electron-Deficient Alkenes via Phenyl Selenide Transfer

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Abstract: Photolysis of 2-phenylseleno-1,3-dithiane in the presence of electron-deficient alkenes led to formation of addition products. These reactions illustrate the second reported case of radical atom transfer addition arising from a heteroatom-stabilized radical. Copyright © 1996 Elsevier Science Ltd

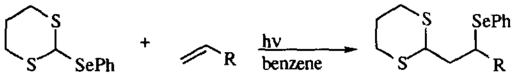
Atom-transfer radical addition reactions have recently led to the development of powerful carbon-carbon bond forming methods. Virtually all of these methods have involved the addition of electrophilic radicals to electron-rich alkenes and alkynes.[1] The reactions of highly nucleophilic radicals, where the initially formed radical is stabilized by an adjacent heteroatom, are an area of active study by several research groups.[2] However, there have been no examples of atom-transfer reactions involving the addition of a heteroatom-stabilized radical, other than the intramolecular addition of acyl tellurides to alkenes.[3] Atom-transfer radical additions arising from α-iodo ethers, sulfides, or amines would presumably be highly problematic due to the high ionic lability of these species, which often precludes their synthesis (Eq. 1). We proposed that this problem might be circumvented through use of a phenylseleno group, given the relatively poor leaving group ability of this functionality.

Eq. 1

$$:Z\cdot CH_2I \longrightarrow {}^{+}Z{=}CH_2 + I^- \qquad Z = RO, RS, R_2N$$

We chose to test this premise using 2-phenylseleno-1,3-dithiane[4] (**1**), given its straightforward synthesis, as well as the known synthetic utility of the dithiane as a carbonyl protecting group.[5] Intramolecular radical addition of a 1,3-dithioxolane to an alkene has been reported[6] and the similar oxygen-substituted dimethoxymethyl radical has been generated from dimethoxyphenylthiomethane, and added to electron-deficient alkenes, with the resulting radical trapped by allyltributylstannane in a non- "atom-transfer" process.[7]

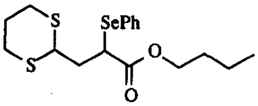
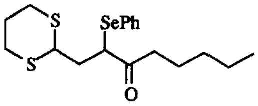
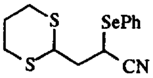
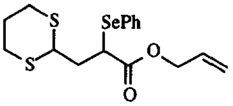
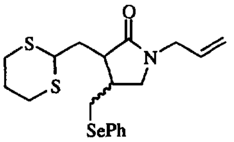
Eq. 2



Successful examples of the photolytic addition of 2-phenylseleno-1,3-dithiane (Eq. 2) are shown in Table I. Typically, 0.5 mmol of 2-phenylseleno-1,3-dithiane and 3 mmol of alkene were dissolved in 2 mL of benzene in a screw-cap Pyrex tube. The mixture was deoxygenated by bubbling Ar for 15 min, and photolyzed for 12 h with a 450-W Hanovia lamp. Yields shown are for products isolated by MPLC and fully characterized. This reaction was successful only when electron-deficient alkenes were employed: Reaction of **1** with 1-octene or butyl vinyl ether failed to generate any detectable addition products. The attempted reaction of **1** with a more highly substituted unsaturated ketone, 2-cyclohexen-1-one, or nitrile, methacrylonitrile, also failed. While the reaction of **1** with allyl acrylate yielded a complex mixture of products, GC/MS analysis indicated that only one product with the molecular weight corresponding to addition was obtained, and isolation of this product allowed us to identify it as the simple addition product shown. No products arising from addition of the 1,3-dithian-2-yl radical accompanied by cyclization prior to phenyl selenide transfer were detected, as might be expected given the resistance which similar ester radicals have shown towards cyclization.[8] On the other hand, the addition of **1** to N,N-diallyl acrylamide yielded only products in which addition was accompanied by cyclization, again as expected.[8,9]

In addition to the mechanistic novelty of this process, these reactions should also be of value in synthesis, given that they allow for introduction of a carbonyl group, protected as its dithiane derivative, and a phenylseleno group, which is also of value in subsequent transformations.

Table I.

ALKENE	PRODUCT	YIELD
Butyl Acrylate		75%
2-Octen-3-one		66%
Acrylonitrile		62%
Allyl Acrylate		20%
N,N-Diallyl Acrylamide		44% (4:1 ratio of diastereomers)

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