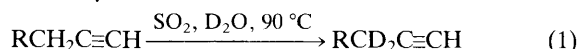


Facile Sulphur Dioxide-catalysed Hydrogen–Deuterium Exchange at the Position α to the Triple Bond in Terminal Alkynes

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*Department of Chemistry, University of California, Berkeley and the Materials and Molecular Research Division, Lawrence Berkeley Laboratory, Berkeley, California 94720, U.S.A.*Sulphur dioxide in deuterium oxide catalyses the regioselective exchange of the hydrogen atoms α to the triple bond in terminal alkynes for deuterium in the presence of other functionality.

The selective deuterium labelling of organic compounds is of great utility in mechanistic studies, as an aid in structural elucidation, for biochemical tracer work, and in other investigations in which an identifiable hydrogen atom is required.^{1,2} We report here that sulphur dioxide in deuterium oxide catalyses not only the exchange of allylic hydrogen atoms for deuterium as reported,³ but also that of those α to the triple bond in terminal alkynes [reaction (1)]. Alkynes have great synthetic potential,⁴ so this method should significantly augment methods available for the specific introduction of hydrogen isotopes into organic molecules.



In a typical experiment a medium-pressure Fisher–Porter bottle was charged with the alkyne (usually 5 mmol) and spectral grade D_2O (500 mmol), cooled to -78°C in a solid CO_2 –acetone bath. SO_2 (ca. 10 ml) was condensed into the reactor, the cooling bath was removed, and the sealed

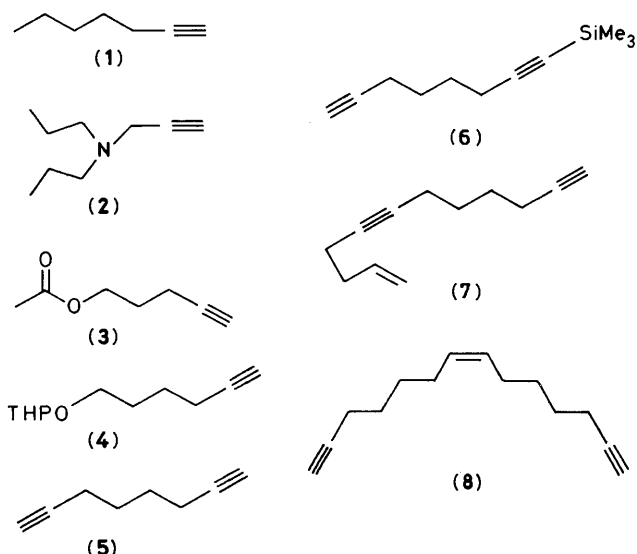
apparatus was slowly warmed to 90 – 95°C behind a safety shield (the internal pressure often reached 125 – 150 lb in^{-2}). The two-phase system was stirred at 90 – 95°C for 36 – 48 h . After cooling to room temperature, the SO_2 was slowly allowed to evaporate. Work-up consisted of either direct extraction with solvent or neutralization followed by extraction. Recovery of deuterated material was generally good to excellent (60 – 80%). The results are summarized in Table 1.

The reaction appears to be considerably slower than that involving only alkenes,³ but nevertheless ultimately equally efficient and selective. Thus, deuterium incorporation into the terminal position, or positions other than allylic or α to the triple bond could not be detected [mass spectrum (m.s.), ^1H and ^{13}C n.m.r.]. Internal alkynes, such as ethyl but-2-ynoate or 1-phenylbut-1-yne, showed only very little H–D exchange, whereas trimethylsilylation as in 1,8-bis(trimethylsilyl)octa-

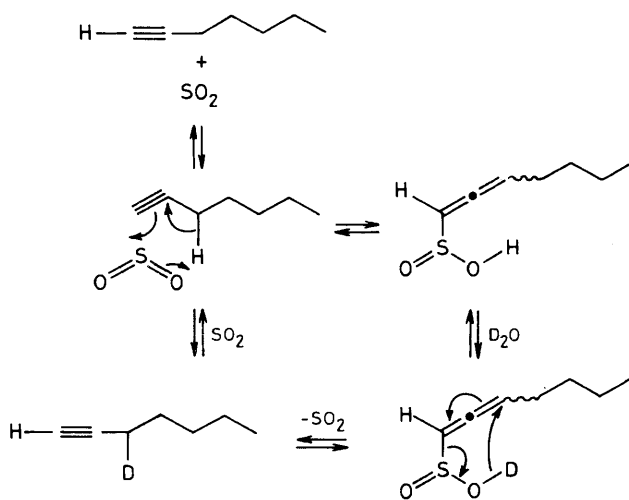
Table 1. H–D exchange in terminal alkynes.

Alkyne	Molar ratio D_2O : alkyne	Reaction time/h	% Deuterium incorporation (^1H n.m.r.) ^g
(1)	10:1	(11 days)	80
(2) ^a	100:1	36	15
(3) ^b	183:1	42	30
(4) ^c	100:1	48	66
(5)	366:1 ^f	48	56
(6)	183:1	48	64
(7) ^d	266:1 ^f	12	75
(8) ^e	160:1 ^f	48	54

^a Lit.⁵ ^b Lit.⁶ ^c Lit.⁷ THP = tetrahydropyran-2-yl. Only the free alcohol was isolated. ^d Lit.⁸ ^e Lit.⁹ Starting material was recovered as a 73:27 *trans-cis* mixture.¹⁰ ^f The reaction was carried out in two stages, using half of the D_2O in each for half the time indicated. ^g Results corroborated by g.c.–m.s. (fused silica capillary column; HP 5880A gas chromatograph, HP 5970A mass selective detector in selected ion monitoring mode).



THP = tetrahydropyran-2-yl.



Scheme 1

1,7-diyne or compound (6) completely suppressed it, suggesting further synthetic applications. Compounds (7) and (8) lead to octadeuteriated products, employed in mechanistic work connected with ($\eta^5\text{-C}_5\text{H}_5$)Co(CO)₂-mediated enediyne [2 + 2 + 2] cycloadditions.^{8,9} Finally, repeated application of the experimental procedure should readily furnish highly deuterium-enriched products, if desired.

Mechanistically, we propose a sequence analogous to that postulated³ for allylic exchange (Scheme 1). It explains the

pronounced steric retardation of terminal blocking and perhaps the slowness of the transformation in entry 2 (Table 1), if negative charge builds up next to the nitrogen in the transition state.¹¹

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