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NAMES FOR MUONIUM AND HYDROGEN ATOMS AND THEIR IONS

(IUPAC Recommendations 2001)

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Abstract: Muons are short-lived species with an elementary positive or negative charge and a mass 207 times that of the electron. These recommendations concern positive muons, given the short lifetime of negative muons. A positive muon mimics a light hydrogen nucleus, and names are given in analogy to existing names for hydrogen-containing compounds. A particle consisting of a positive muon and an electron (μ^+e^-) is named "muonium" and has the symbol Mu. Examples: "muonium chloride," MuCl, is the equivalent of deuterium chloride, ^{2}HCl or DCl; "muoniomethane", CH_3Mu, is the product of the muoniation of methane; and NaMu is "sodium muonide."

INTRODUCTION

The name "muon" is used in physics for the short-lived species that belong to the lepton family and that are designated with the nuclear symbols μ^+ and μ^-, each having a mass 207 times that of the electron [1]. Muons are produced artificially from high-energy proton beams at specialized facilities. A negative muon can replace an electron in the 1s orbital of an atom, in which case this atom is called a "muonic" atom: $H^+\mu^-$ is "muonic hydrogen". Replacement of an electron by a muon in other atoms is possible. Negative muons have a shorter life time than positive muons and are currently thought not to be chemically relevant [1]. This recommendation is therefore concerned with *positive* muons.

During its lifetime of ca. 2 μs a positive muon can take on the role of a "light" hydrogen nucleus, and in the literature one finds the name "muonium" and the symbol "Mu" for the particle μ^+e^- [1,2]. Muonium is formed near the end of the track of a positive muon when it abstracts an electron [1], and can be regarded as a light isotope of hydrogen. Although chemical reactions of muonium atoms have been studied for more than two decades, the nomenclature of muonium and related species has not been addressed by IUPAC. In this recommendation, names are given for muonium ions in analogy to the existing names for hydrogen and its isotopes [3].

NOMENCLATURE

A summary of muonium and hydrogen nomenclature is given in Table 1.

These recommendations lead to the following related terms:

- "muonido" indicates muonium as a ligand (*cf*. hydrido);
- "muonio" is the prefix (*cf*. deuterio) used in substitutive nomenclature to denote replacement of hydrogen by muonium; this process is called "muoniation";
- "muonation" is the equivalent of protonation.

Table 1 Comparison of names and symbols of muonium species with hydrogen equivalents [3].

Isotope	Particle	Name	Symbol
Muonium			
	μ^+	muon	Mu^+
	μ^+e^-	muonium	$Mu^\bullet$
	$\mu^+(e^-)_2$	muonide	Mu^-
Protium			
	p^+	proton	$^1H^+$
	p^+e^-	protium	$^1H^\bullet$
	$p^+(e^-)_2$	protide	$^1H^-$
Deuterium			
	d^+	deuteron	$^2H^+$ (D^+)
	d^+e^-	deuterium	$^2H^\bullet$ ($D^\bullet$)
	$d^+(e^-)_2$	deuteride	$^2H^-$ (D^-)
Tritium			
	t^+	triton	$^3H^+$ (T^+)
	t^+e^-	tritium	$^3H^\bullet$ ($T^\bullet$)
	$t^+(e^-)_2$	tritide	$^3H^-$ (T^-)
Hydrogen (naturally occurring mixture of isotopes)			
		hydron	H^+
		hydrogen	$H^\bullet$
		hydride	H^-

Examples

1. MuCl is named "muonium chloride", which yields positive muons (or muonium ions), Mu^+, and chloride ions, Cl^-, upon dissociation. A hydrogen equivalent would be "deuterium chloride", ^{2}HCl or DCl.
2. CH_3Mu, "muoniomethane", is a product of muoniation of methane, while tritiation leads to "tritiomethane".
3. NaMu is named "sodium muonide".
4. ^{1}HMuO is named "muonium protium oxide"; for an unspecified isotope of hydrogen the name changes to "hydrogen muonium oxide". A substitutive name is "muoniooxidane". MuO^- is named "muoniumoxide(1–)", or "muoniooxidanide".
5. As the systematic name of $^1H_2$ is "diprotium", ^{1}HMu is named "muonium protium", HMu "hydrogen muonium" and Mu_2 "dimuonium". Note that the particle $\mu^+\mu^-$ would be named "muonic muonium" [2].
6. Addition of muonium to a double bond results in the formation of a radical. For example, the reaction of $Mu^\bullet$ with benzene could yield "6-muoniocyclohexa-2,4-dien-1-yl" or "4-muoniocyclohexa-2,5-dien-1-yl".

REFERENCES AND NOTES

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3. J. F. Bunnett and R. A. Y. Jones. *Pure Appl. Chem.* **60**, 1115–1116 (1988).