Introduction

The relevance of gem-dihydroperoxides to peroxodic antimarial agents stimulated initial interest in this class of compounds.\(^1\)–\(^5\) Apart from their biological activities,\(^6\)–\(^7\) gem-dihydroperoxides have been established as important building blocks in synthetic chemistry, for example the preparation of organic peroxides, trioxanes, tetraoxanes, spirobisperoxyketal, and dicarboxylic diesters.\(^4\)–\(^7\)\(^,\)**\(^8\)**\(\text{gem-}\)Dihydroperoxides can also be employed as oxidizing agents under various conditions to perform transformations such as epoxidation\(^1\)–\(^5\) and sulfoxidation.\(^2\)–\(^5\)\(^,\)**\(^9\)** In addition, in situ decomposition of gem-dihydroperoxides can generate singlet oxygen as the active oxidant\(^8\)\(^,\)**\(^10\)** in olefin oxidation, for example.\(^11\)** The ability of gem-dihydroperoxides to generate radicals allows them to be furthermore exploited as radical initiators,\(^2\)–\(^5\) for example methyl ethyl ketone peroxide is used in the manufacturing of acrylic resins, reinforced plastics, and unsaturated polyester resins.\(^6\)**

Reaction times can generally be reduced upon introduction of a catalyst, amongst which molecular iodine\(^15\)** as well as numerous transition-metal Lewis acids have proven effective.\(^4\)–\(^5\)\(^,\)**\(^8\)–\(^16\)\(^,\)**\(^17\)** Brønsted acids are comparably active as either homogeneous (sulfuric acid\(^3\)) or heterogeneous catalysts, for example silica-sulfuric acid\(^2\) or triflic-acid-functionalized silica-coated ferromagnetic nanoparticles.\(^18\)**

Abstracts

(A) Dussault and co-workers\(^19\)** prepared primary and secondary alkyl hydroperoxides in moderate to high yields (48–79%) via double alkylation of 1,1-dihydroperoxides, followed by acid-catalyzed hydrolysis of the resulting strained cyclic alkylated gem-bishydroperoxides (bisperoxyacetals).

(B) 1-Hydroxy-1′-alkoxyperoxides were prepared by Terent’ev et al.\(^6\)** in moderate yield (40–64%) through iodine-catalyzed cross-coupling of gem-bishydroperoxides and acetals. This cross-coupling is also effective upon substitution of the acetal with an enol ether.

(C) Symmetrical and asymmetrical tetraoxanes can be prepared from gem-dihydroperoxides. The combination of a gem-dihydroperoxide and its carbonyl analogue in the presence of fluoroboric acid and hydrogen peroxide favors formation of symmetrical tetraoxanes.\(^20\)** Similarly, asymmetrical tetraoxanes are obtained when two non-identical carbonyl compounds are introduced.\(^7\)**
(D) Jakka et al.\textsuperscript{1} reported the epoxidation of various \(\alpha,\beta\)-unsaturated ketones utilizing cyclohexyldiene-bishydroperoxide as a stoichiometric oxidant under Weitz–Scheffer reaction conditions (aqueous, alkaline).

\[
\text{R} \begin{array}{c}
\text{H} \\
\text{R} \\
\end{array} \begin{array}{c}
\text{O} \\
\text{OH} \\
\end{array} \rightarrow \begin{array}{c}
\text{CH}_2 \text{CH}_2 \\
\text{Cl} \\
\end{array} \begin{array}{c}
\text{H} \\
\text{O} \\
\end{array}
\]

(E) Sulfoxidation of thiophenol ethers can be achieved under neutral conditions at ambient temperature, producing sulfoxides in high yields (79–93\%) in less than two hours.\textsuperscript{9}

\[
\begin{array}{c}
\text{R} \\
\end{array} \begin{array}{c}
\text{H} \\
\text{R} \\
\end{array} \begin{array}{c}
\text{OH} \\
\text{OH} \\
\end{array} \rightarrow \begin{array}{c}
\text{Me} \\
\end{array} \begin{array}{c}
\text{Cl} \\
\text{Me} \\
\end{array}
\]

(F) Subsequent to observing the oxidation of triphenylphosphine to triphenylphosphine oxide in the presence of 1,1-dihydroperoxy-cycloododecane, Sekine and co-workers\textsuperscript{21} prepared oligodeoxyribonucleotides in a similar fashion via the oxidation of phosphate intermediates to their respective phosphate analogues.

\[
\begin{array}{c}
\text{R} \\
\text{R} \\
\text{O} \\
\text{O} \\
\text{O} \\
\text{O} \\
\text{P} \\
\text{B} = \text{nucleobase}
\end{array} \begin{array}{c}
\text{MeCN}, 0 \degree\text{C} \\
\text{aq KOH–1,4-dioxane} \\
\text{r.t., 0.5–5 h} \\
\text{CH}_2\text{Cl}_2–\text{EtOAc (9:1)} \\
\text{r.t., 0.5–2 h} \\
\text{CH}_2\text{Cl}_2–\text{DMSO} (9:1) \\
\text{r.t., 90 s}
\end{array}
\]

(G) Dussault and co-workers reported the liberation of singlet oxygen when monoactivated \(gem\)-dihydroperoxide derivatives were exposed to anhydrous alkaline conditions.\textsuperscript{22} If this degradation is performed in the presence of an organic substrate, an oxidative transformation of the substrate is observed.\textsuperscript{10} This protocol also allows for oxidative cleavage of olefinic substrates to yield aldehydes or ketones in moderate to high yields (35–82\%).\textsuperscript{11}

\[
\begin{array}{c}
\text{R} \\
\text{R} \\
\text{C} = \text{O} \\
\text{HO} \\
\text{Ph} \\
\text{Ph} \\
\text{O} \\
\text{O} \\
\text{O} \\
\text{O} \\
\text{P} \\
\text{B} = \text{nucleobase}
\end{array} \begin{array}{c}
\text{MeCN}, 0 \degree\text{C} \\
\text{TBAF} \\
\text{1O}_2 \\
\text{iso-pentyl (93\%)}
\end{array}
\]

References