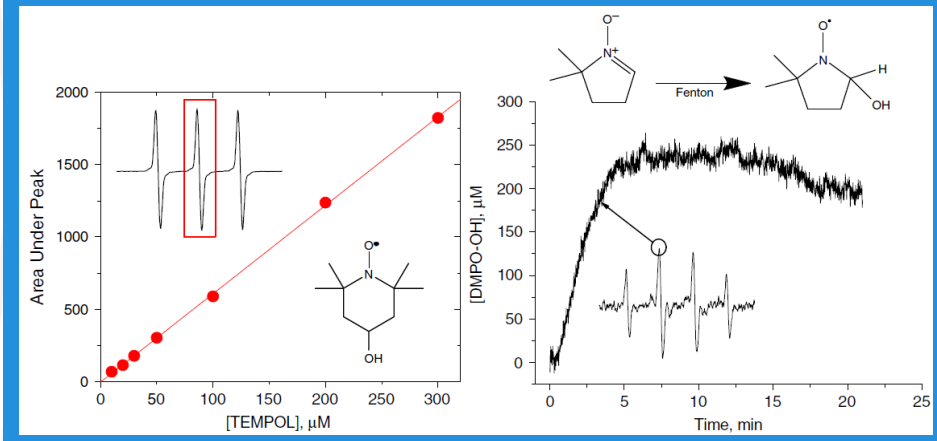
EPR-spectroscopy for detection of free radicals and reactive oxygen species

Free radicals are particles possessing unpaired electrons, hence they are paramagnetic and highly reactive. They can be neutral or charged (ion-radicals), with one or more unpaired electrons (polyradicals), short-living (fractions of a second) or long-living (up to several years lifetime) at 298 K, solid, liquid or gaseous.

Free radicals play a vital role in redox, photochemical [1-3] and catalytic [4, 5] processes, as well as in main industrial processes: polymerization, telomerization, pyrolysis, cracking, heterogeneous catalysis. In order to stabilize the radicals, low temperature techniques are widely used, for example – liquid nitrogen cooling.
Long-living (stable) free radicals are paramagnetic compounds with highly delocalized free electrons and sterically hindered reaction centers [6].

Spin trapping is one of the most important methods in biological and medical research since it allows to detect and identify free radicals generated in living cells and tissues. Among them are the superoxide and hydroxyl radicals (the so-called Reactive Oxygen Species, ROS) as well as nitrogen oxide [7].



Free radicals and particularly – ROS formation and degradation are important chemical processes occurring in human body. Spin trapping technique allows to study the antioxidant properties of various substances and to detect ROS as well as some other types of free radicals [8]. Various chemical reagents (PBN, DMPO) are used as spin traps [9].

Figure 1 – Ascorbyl and DMPO-OH radical EPR spectrum (radical was generated during the Fenton-like reaction with Cu2+)

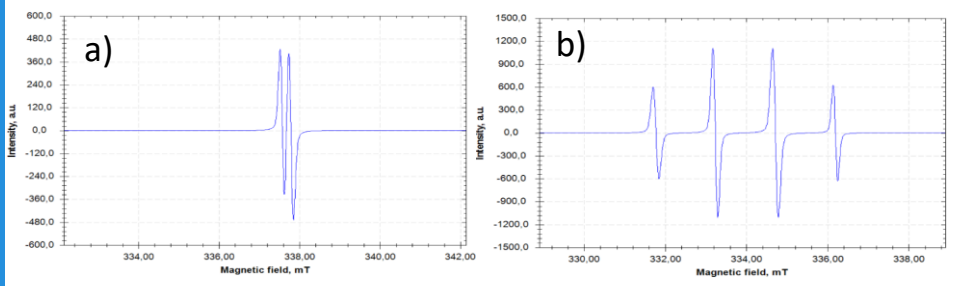
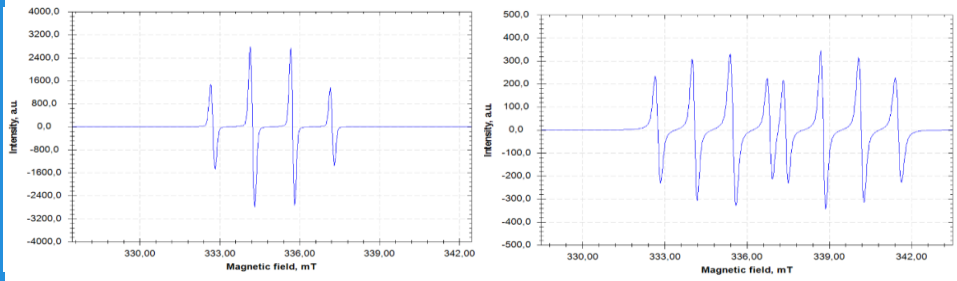


Figure 2 – DMPO-OH and DEPMPO-OH EPR spectra (radicals were generated by UV-irradiation)



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Some examples of using benchtop EPR spectrometer SpinScan X for free radicals detection:

1) Ascorbyl radical is generated during the ascorbic acid oxidation – activation by virtually any reactive species occurring in biological media (fig.1a).

2) hydroxyl radicals detection during the Fenton-like reaction with Cu 2+. Generation at pH 6.0, 1 mM Cu2+, 1 mM ascorbic acid and 1 mM H2O2 with 100 mM DMPO as a spin trap (fig.1b).

3) hydroxyl radicals detection during the UV irradiation (λ=395 nm) of 10 mM H2O2 with 100 mM DMPO or 50 mM DEPMPO (fig 2).

Examples of experimental studies of oxidative processes by the EPR method using a benchtop CW X-band spectrometer demonstrate the broad possibilities of its practical applications. The method and equipment make it possible to effectively monitor the accumulation of free radicals in the sample of interest. In addition, due to the wide functionality of the SPINSCAN X EPR spectrometer, the EPR technique can also be used for deeper scientific research and study of the mechanisms of initiation and occurrence of redox reactions as well as in the creation of new oxidation-stable products.

Innovation
EPR spectrometer
Spinscan X