

EPR SPECTRA OF PHTHALOCYANINES IN DIMETHYL SULFOXIDE

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Using EPR for six phthalocyanines dissolved in dimethyl sulfoxide free radical formation was measured. Free radical formation as a result of illumination of phthalocyanines is important for photodynamic therapy of cancer.

INTRODUCTION

Previously the yields of triplet state formation for seven various phthalocyanines unsubstituted by metal and substituted by Mg, Zn, Cu and Al in dimethyl sulfoxide (DMSO) solutions were compared on the basis of time resolved photothermal measurements (Frąckowiak, Planner, Waszkowiak, Boguta, Ion & Wiktorowicz, 2001).

The destruction of neoplastic (malignant) cells, potentially can occur by both mechanisms: type 1 - direct interaction of sensitizer with tissue and type 2 - interaction with singlet oxygen ($^1\text{O}_2$) generated, through, the triplet state of the sensitizing dye (Rosenthal, 1991, Frąckowiak, Planner & Wiktorowicz, 2001, Frąckowiak, Planner, Ion & Wiktorowicz, 1998, Henderson & Dougherty, 1992). Effective sensitizers in addition to acting through high yield of triplet states also could act through efficient creation of free radicals (Frąckowiak, Planner, Ion & Wiktorowicz, 1998).

Therefore in this paper the formation of free radicals was investigated for the same set of phthalocyanines dissolved in DMSO studied previously (Frąckowiak, Planner, Waszkowiak, Boguta, Ion & Wiktorowicz, 2001, Frąckowiak, Planner, Waszkowiak, Boguta, Ion & Wiktorowicz, 2001).

MATERIALS AND METHODS

The molecular structures of dyes that were investigated are shown in Fig. 1. The MgPc, CuPc and Solar phthalocyanines (Pc) (Fig. 1) were prepared according to the procedure described by Ion (Ion, 1999). Other Pcs (substituted by Zn and Al) were

purchased from Sigma-Aldrich and used without further purification. As a solvent dimethyl sulfoxide (DMSO) was used. The concentrations of the dyes were identical for all samples ($3 \cdot 10^{-4}$ M).

EPR studies were done using Radiopan SE/x-2540 spectrometer with a RCX - 660a resonator operating in the TM_{110} mode. In a front wall of the resonator there is 8 mm in diameter hole allowing illumination of sample during the experiment. For illumination a 150W halogen projector lamp was used.

RESULTS

Fig. 2 shows the results of the EPR measurements. In previous studies (Frąckowiak, Waszkowiak, Manikowski, Ion, Cofta, & Wiktorowicz, 2001) the unsubstituted Pcs (H_2Pc and Solar Pc) exhibit only a rather weak EPR signals, probably due to an admixture of small amounts of Cu^{2+} ions. The EPR signal of CoPc, under used conditions was not measurable. A strong EPR signal is usually observed in very viscous media and at high dyes concentrations (Frąckowiak, Goc & Waszkowiak, 2000). Between actually investigated Pcs, only AlPc was paramagnetic in the ground state. It exhibits EPR spectra even at low ($3 \cdot 10^{-4}$) dye concentration (Fig.2). The interaction of the Al^{3+} ion with the conjugated bond system of Pc causes the paramagnetism of such molecules. The AlPcCl I dissolved in DMSO exhibits an EPR signal with line width $\Delta B = 0.53$ mT and $g = 2.0016$. Additional peripheral substituents in AlPcCl II (Fig.1e) attenuate ion-conjugated bonds interactions resulting in a 8-times decrease of the EPR signal and a shift of the g-factor towards higher values (2.0021)

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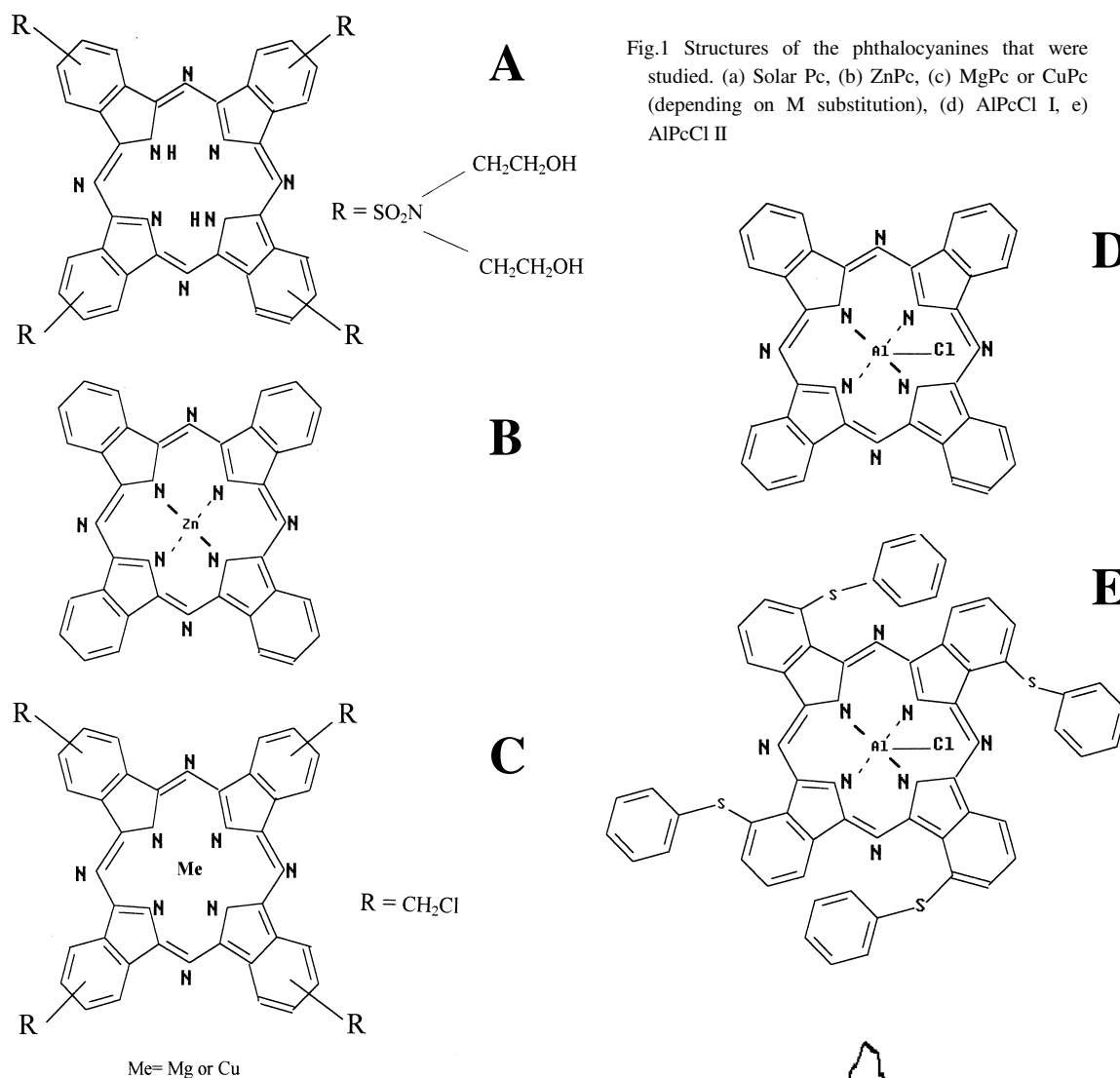
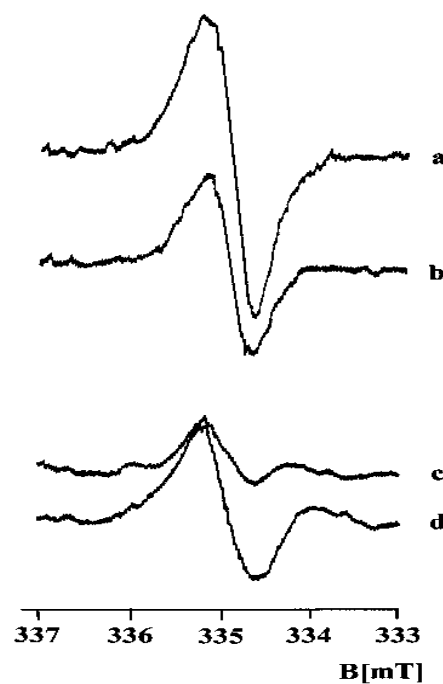


Fig.1 Structures of the phthalocyanines that were studied. (a) Solar Pc, (b) ZnPc, (c) MgPc or CuPc (depending on M substitution), (d) AlPcCl I, e) AlPcCl II

Fig.2 First derivative of EPR absorption spectra measured at room temperature. Microwave attenuation 10dB. Traces a and d were measured during illumination of the samples. Top spectra AlPcCl I: modulation amplitude 0.1 mT, $g=2.0016$, microwave frequency $\nu = 9.3852$. Bottom spectra AlPcCl II, modulation amplitude 0.4 mT, $g = 2.0021$, $\Delta B = 0.6$ mT, microwave frequency $\nu = 9.3875$. Exertion significantly increases CI values. Forwards subgroup has the lowest CI increase during the test, which point to best form of the payers.

whereas the line width is almost unchanged.

Illumination of the samples caused an increase in the concentration of paramagnetic species to the same extent for both Pcs. For the other investigated metal substituted Pcs (Zn, Cu and Mg) a light induced EPR signal was not observed. The Al substituted Pcs dissolved in DMSO were are more efficient source of free radical generation than the other Pcs. All of the studied Pcs exhibit a efficient generation of triplet states by intersystem (Singlet



→ Triplet) crossing transition (Frąckowiak, Planner, Waszkowiak, Boguta, Ion & Wiktorowicz, 2001), therefore they can be used as sensitizers in photodynamic therapy (Frąckowiak & Planner, 2000). The free radical formation in the solvent shows that AlPcCl (1) (Fig.1d) is an especially promising candidate for use in medicine.

Acknowledgments

These studies were supported by grant DS 62176 from Poznań University of Technology.

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