

Effect of electric field on positronium production in liquids

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A decrease is observed in the probability of production of a positronium atom in nonpolar liquids under the influence of external electric fields. An explanation is offered within the framework of the track model of positronium production.

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At the present time there exist two models for the production of the positronium atom in condensed media. According to the Ore model,^[1] positronium is produced by capture of an electron by a positron in the neutral medium of the molecule. The recently proposed track model^[2,3] considers the production of positronium as a result of the investigation of a positron with one of the track electrons. One can choose between these two models by investigating the influence of an external electric field on the positronium production process. The first model predicts that the electric field can only increase the positronium yield.^[1] Within the framework of the second model, one can expect the opposite effect, since the field impedes the recombination of the charges.

We report here a study, for the first time, of the influence of an electric field on the positronium production probability in the liquids tetramethylsilane, isooctane, *n*-hexane, benzene, and hexafluorobenzene. The field intensity E ranged from 0 to 40 kV/cm. The investigated liquid and the positron source were placed between capacitor plates spaced 0.5 cm apart. In the experiment we measured the intensity of the long-lived component of the temporal annihilation spectrum of the component, I_2 (%), which is numerically equal to the yield of orthopositronium. The resolution time of the setup was ~ 0.6 nsec. All the measurements were performed at room temperature. As seen from the figure, in all cases with the exception of hexafluorobenzene, I_2 decreases with increasing intensity of the electric field,

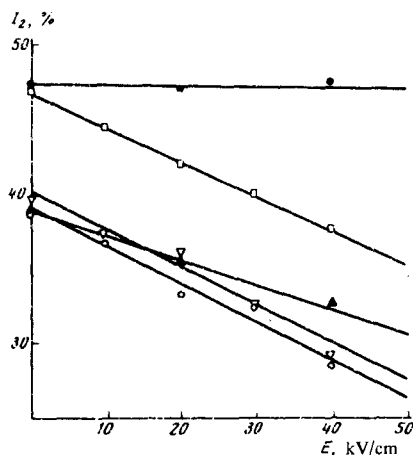


FIG. 1. Plot of I_2 against E for tetramethylsilane (□), isooctane (▽), *n*-hexane (○), benzene (▲), and hexafluorobenzene (●).

thus confirming the track model. For a quantitative interpretation of the results we recognize that within the framework of the track model positronium production is similar to the process of recombination of an electron with a parent ion in radiation-chemical processes. In the latter case, as is well known,^[4] the recombination probability in an external electric field decreases by an amount P_E . For small E we have in accordance with^[4]

$$P_E = \exp(-r_c/r_0) (er_c/2kT) E, \quad (1)$$

where r_0 is the initial distance between charges, $r_c = e^2/\epsilon kT$ is the critical distance corresponding to equality of the energy of the Coulomb interaction of the charges to the thermal energy, and ϵ is the dielectric constant of the medium.

The influence of the electric field on the yield of the ortho-positronium should be described, with (1) taken into account, by the formula

$$I_2(E)/I_2(0) = 1 - \exp(-r_c/r_0) (er_c/2kT) E. \quad (2)$$

Using the data of the figure and formula (2), we can calculate the initial distance between the electron and the positron in the investigated liquids. In all cases (with the exception of the hexafluorobenzene) the calculations yield approximately the same value, $r_0 \approx 100$ Å, which is close to the corresponding distances between the charges in the track of a fast electron in a nonpolar liquid, a distance known from radiation-chemistry experiments.^[4] It appears that the absence of the effect in hexafluorobenzene is due to the fact that in this case we get electron capture with production of the anion radicals $C_6F_6^-$,^[5] which can significantly change the primary spatial distribution of the charges. We note in conclusion that the results of^[6,7] on the effect of E on I_2 in the solid phase can also be explained from the considered points of view.

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