EFFECTS OF IRRADIATION ON
COMBUSTION OF ORGANIC COMPOUNDS:
A LITERATURE SURVEY

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ABSTRACT

Information found in the literature indicates that combustion efficiency and flame speed are increased when fuel-air mixtures are irradiated with very intense beta or gamma sources. In order to show any noticeable effect, however, radiation fields of at least 2000 Ci per cubic inch must be present.

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INTRODUCTION

Organic compounds are used in many processes involving highly radioactive isotopes. Some of these are combustible compounds which may present a fire hazard for the hot cell, cave, or canyon in which they are contained. Irradiation is known to produce compounds and fragments (radicals) which may speed the combustion of organics or cause them to become more flammable. This literature survey is intended to evaluate the possible increased fire hazard of organic compounds due to irradiation and is part of a study requested by the Division of Operational Safety of the U. S. Atomic Energy Commission.^[1]

SUMMARY AND CONCLUSIONS

Several significant references were found concerning the effect of irradiation on combustion of organic compounds. Studies show that the combustion efficiency and flame speed are increased when fuel-air mixtures are irradiated with very intense beta sources. Gamma irradiation was also found to increase the rate of propane oxidations. Burning rates for solid fuel propellant were also increased by irradiation.

In each of these studies the minimum amount of radiation necessary to show any noticeable effect is very high. Most operations performed in hot cells or canyons would not involve organic solvents in a radiation field intense enough

(≈ 2000 Ci of β per cubic inch) to significantly affect combustion rate.

DISCUSSION

Irradiation of combustible gas mixtures has been found to increase combustion efficiency. Cullen and Gluckstein^[2] studied the effects of relatively weak beta radiation sources (100 to 2000 curies) on combustion of propane-air mixtures. They found no significant changes in the flame speed at these low source intensities. However they did observe slightly increased reaction rates in the combustor.

Much more intense beta radiation sources were used by Churchill *et al.*^[3] to irradiate propane-air Bunsen flames. Beta radiation from a 10,000 curie gold source increased the flame speed by almost 50%. They attribute this increased flame speed to the formation of ion pairs by interaction of the gas mixture with the beta particles. These authors also report^[4] an increase in the amount of CH and C₂ radicals in the flames due to irradiation.

Liebenthal *et al.*^[5] irradiated mixtures of propane and oxygen at several temperatures in the range of 95 to 350 °C with a ⁶⁰Co gamma source. The yields of HCHO, AcH, and MeOH increased significantly under γ -irradiation, sometimes as much as 100 to 200%. Radiation also increased the overall reaction rate.

Research on the effects of ionizing radiation on combustion engine performance at the University of Michigan^[6] has shown that β -radiation has little effect on combustion. Irradiation of the combustion chamber of a diesel engine with 1200 curies of ¹⁰⁹Pd had little influence on the performance of the engine.^[7]

Matos and Johnson^[8] have compared the performance of γ -irradiated (to 1500 rads) rocket fuel with that of non-irradiated fuel. No significant difference was found when tested under similar conditions with specific impulse as the criterion of comparison.

The effect of irradiation on combustion of solid fuel propellants has been studied by several workers.^[9,10] Radiation was observed to decrease the burning rate of the polystyrene binder, while the rates increased for the ammonium perchlorate oxidizer and solid mixtures of oxidizer and binder. Only for very large radiation doses (300 to 400 megarads) was any change in the combustion rate observed.

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