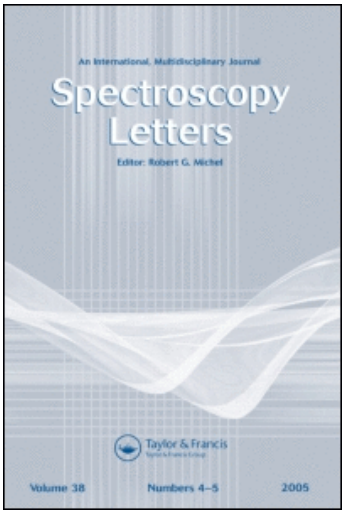

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Chemistry in Lasers. XIII. Energy Storage and Utilization of Group VIII-A Hydrides as Laser Active Media

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CHEMISTRY IN LASERS. XIII. ENERGY STORAGE AND UTILIZATION OF GROUP VIII-A HYDRIDES AS LASER ACTIVE MEDIA

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ABSTRACT

The feasibility of utilizing the energetic capability of optical resonant cavities for new compound formation is examined with a positive conclusion. Unlike photochemical reactions which yield products which are thermodynamically stable in the absence of the cavity energy field, the present considerations are centered around compounds which are highly unstable under ordinary conditions. As specific examples the Group VIII-A hydrides are discussed, including their application as laser active media. Principal advantages of noble gas hydrides are lack of a bound ground elec-

tronic state (comparable with excimers), for less corrosiveness than Group VIII-A halides (or fluorine containing laser media), wide range of tunability including the soft X-ray/VUV region, and lack of decomposition of the compounds involved upon prolonged use (superior to dyes). Applicability of new lasers utilizing Group VIII-A hydrides is discussed, in relation to energy release (fusion) and metal-photon interaction problems.

(End of Abstract)

In the preceeding paper dealing with chemistry and lasers (1) we discussed a two-step controlled nuclear fusion process based on pellets constructed in part from doubly isotopic boron hydrides. The first step, laser driven heavy hydrogen fusion, which is initiator for the boron reaction, falls into the broad category of schemes that would benefit from some working fascimile of the frequently quoted Brand X, or "ideal" laser. In the quest for suitable materials to provide high output power, tunability, short wavelength, and if possible exceptional stability, various shortcomings of existing materials become readily apparent. By resorting to the concept of strongly coupling the radiation field in an optical resonant cavity with a suitable molecular ensemble, discussed earlier (2), the feasibility of preparing some optimal compounds in situ became an evident route of novel significance. The

simplest chemical element is hydrogen, and it is an ideal counterpart of noble gases for the present application due to the lack of a stable hydride with any of them. Whereas it is instructive to pursue the details of thermodynamic stability vs. instability based on known bond energetics, it would only serve to expand the present communication not only to an unfavorable length, but also in a tangential manner as far as the main topic is concerned; the excellent and provoking text by Dasent (3) should be consulted in all probability in a supplementary fashion, however.

The question of available energy levels is of focal interest, inasmuch as hyperpolarization of the Group VIII-A elements will produce the necessary orbital overlap for hydride formation--albeit with varying facility depending on the number of electrons, the extent of the electron cloud, hence: on the atomic number. To consider available energy levels, perhaps paradoxically, one is referred not to general texts on quantum chemistry, but to Kittel's "Thermal Physics" (4). The crucial trade-off of ordinary molecular orbitals to the alternate set available in the high energy density region of the OR cavity is readily acceptable once the essentially relativistic treatment is adopted, based on photon-cavity interactions, rather than on the usual molecular electronic transition lines.

The soundness of the approach can be gauged from both theoretical (5) and experimental grounds; the latter comes from Stanford University's spectacular development of a free-electron laser (yet to be published), in which a relativistic electron beam creates the energy levels for population inversion by interacting with a periodic magnetic field. Output frequency is reported to be proportional to the square of the e-beam energy, and a similar tuning arrangement is available here. Additional factors influencing tuneability are the over-all pressure, temperature, and above all: composition. With several noble gases in the cavity, staircase tuning to short wavelengths is the facile approach, the hydride formation giving great power capability and flexibility in comparison to Group VIII-A excimers/exciplexes only. Unlike CO_2 (which has been successfully tuned by controlling over-all pressure and added inert gas components), the decomposition products are completely stable and innocuous. A TEA arrangement appears highly promising in view of successful laser action having been observed in pure hydrogen upon electric discharge. A similar arrangement, consisting of electric discharge pumping of noble gas-scintillator dye vapors in an optical cavity has been reported by the present author in 1973 (6).

There are many vital questions that are unanswered as the manuscript reaches its conclusion; such important technological questions as suitable mirror construction for the short wavelength-high power applications have not been touched upon. Before significant practical applications, much basic research on component ratio and composition to achieve particular capabilities and operational characteristics remains to be done. The immediate applications are likely to be in the area of metal-photon interaction, perhaps from considerable distance at suitable frequencies, and pellet excitation. Formidable though these opportunities may seem, the purely chemical aspects involved are difficult to supersede in importance: optical cavity engineered molecular orbitals and preparation with their aid of the henceforth truly non-existent noble gas hydrides.

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