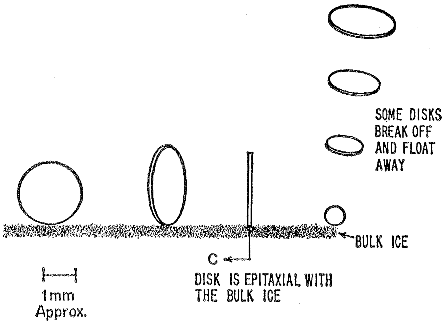

Fig. 1. The growth of attached crystals on polycrystalline bulk ice is observed when the latter is placed in contact with slightly undercooled water (0.01° to 0.03°C). At higher undercooling the growth becomes dendritic. This drawing represents a typical observation ($\Delta T = 0.2°C$ after 1 to 2 minutes).

ers when the water undercools. Turbulent streams and rivers in northern latitudes often are undercooled as much as 0.01°C because of the cooling effect of the free surface which is not covered with ice. There is always ice along the shore and at other places in such streams, and we suggest that the frazil-ice disks form on that ice and are pulled off into the stream.

Schaefer (*6*) reports a concentration of frazil ice approaching 10^6 disks per cubic meter on the Mohawk River where the air temperature was about −20°C and the wind velocity about 3 m/sec. These ice disks form large spongelike masses which gather on rocks and other underwater objects. When a chain, a series of vertical bars, or a wire screen is submerged in water containing frazil-ice particles in suspension, Schaefer reports a build-up on the upstream side which becomes quite thick and prevents water from getting past. This often happens at the trash racks at the intake of a hydroelectric generator system where the accumulation of frazil ice may be so rapid and the effects so damming that the complete power-generating system may be forced out of operation unless effective and continuing measures are employed to remove or prevent such build-up. Schaefer notes (*6*), "nothing is more dramatic than to witness a 30,000 kw hydro[electric] plant removed from the operating electrical network in less than an hour by the accumulation of these tiny frazil ice particles on the intake racks." There has been further research on frazil ice by Arakawa (*7*), but the mechanism of its formation in streams has not been established.

We propose a mechanism for the formation of frazil ice based on the observation of attached disks described above. The moving water in the stream is undercooled by its contact with the cold air, and there is a negative temperature gradient in the stagnant boundary layer on the bulk ice which is always present in the streams. The frazil-ice disks grow out of the ice much like those in Fig. 1, but they break off as they grow into the moving water and never reach the size shown there. The site at which the first disk breaks away is the site of formation of a new disk. This mechanism is capable of generating millions of disks in a very short time.

The same kind of mechanism could operate in metal castings, where grain refinement can be accomplished by stirring (*1*). If a gradient of the driving force for crystallization can be developed in the boundary layer on the solid-liquid interface, then conditions are favorable for growth of attached crystals (*5*). Growth must be retarded on the interface and increase as the attached crystals grow out into the moving liquid. The narrow neck which is characteristic of attached growth is easily ruptured by a small force on the crystal or melted by a current of warm liquid.

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Xenon-Photosensitized Formation of Metastable Nitrogen

Abstract. *Metastable nitrogen molecules are produced by collision with xenon atoms excited with 1470-Å radiation. The photolytically excited species were detected by measuring the rate at which electrons were ejected from a gold surface. Hydrogen was shown to be more efficient than helium in quenching the photo-excited xenon atoms.*

The ejection of electrons from a gold surface by metastable atoms and molecules has been observed and used to study the collisional deactivation of xenon atoms excited by 1470-Å radiation. Nitrogen, hydrogen, and helium were used as collision partners in these deactivation studies.

The apparatus consisted of two parallel planar gold and nickel electrodes (0.5 cm apart) mounted at one end of a cylindrical glass vessel (12 cm in diameter). A lithium fluoride window (13 mm in diameter) was attached with Apiezon wax at the opposite end of the vessel, avoiding line-of-sight irradiation of the electrodes. Pressures of Xe, N_2, H_2, and He were measured with a thermocouple gauge calibrated for each individual gas. A pressure of 2×10^{-7} torr was attained prior to each set of measurements. The Ni electrode was maintained at 4 volts positive with respect to the Au, and currents were measured with an electrometer having a maximum full-scale sensitivity of 1×10^{-13} amperes.

The Xe resonance lamp was similar to the one described by Okabe (*1*). Absorption of the resonance radiation by atmospheric oxygen was avoided by causing dry nitrogen to flow between the windows of the lamp and the reaction vessel. A small amount of radiation scattering in the vessel resulted in a small photoelectric current of about 5×10^{-13} amperes. All current measurements made with absorbing gas present were corrected for this photoelectric effect.

Figure 1*a* is a graph of electron current flow from the Au to Ni electrodes as a function of Xe pressure. The exciting radiation is 1470 Å, since the interposition of a methane filter between the lamp and reaction vessel

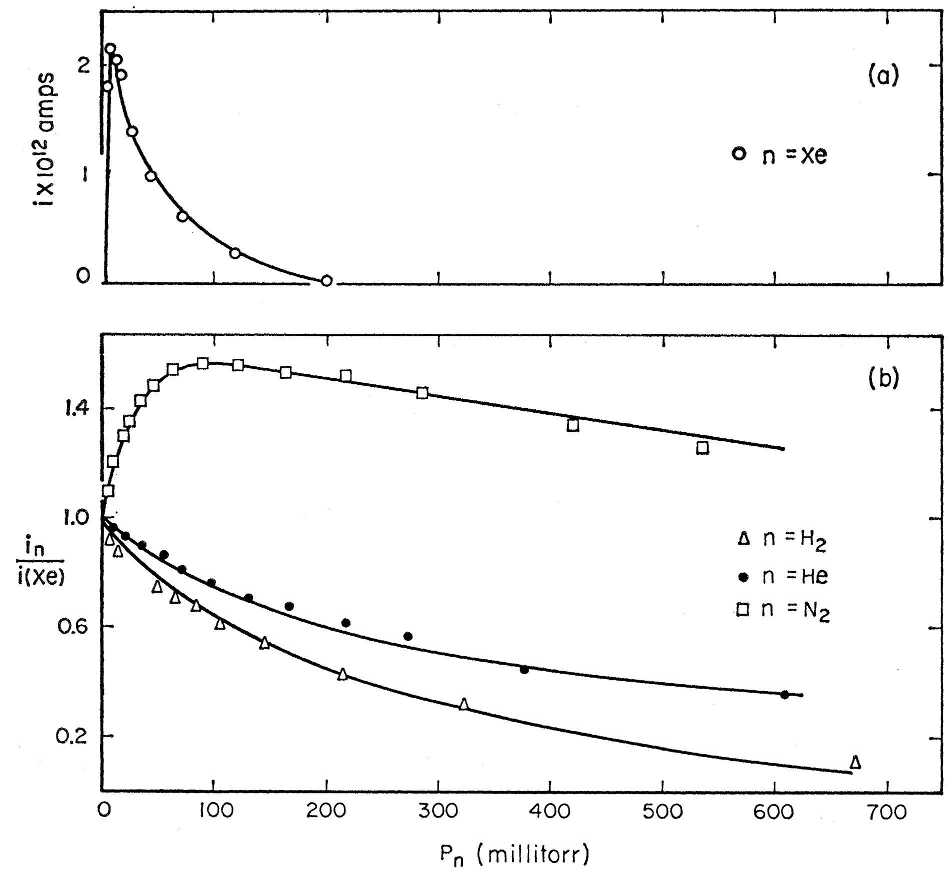

Fig. 1. (*a*) Current flow as a function of xenon pressure. (*b*) Effect of hydrogen, helium, and nitrogen on the ratio $i_n/i(\mathrm{Xe})$.

had no effect on the observed current. Any effects due to the small amount of 1295-Å radiation emitted by the lamp (*1*) are therefore negligibly small. Since the ionization potentials of Xe, H_2, He, and N_2 are all greater than 10 volts, ionization of any of these species in their ground state cannot occur with a 4-volt collection potential and do not contribute to the observed current.

The sharp current increase below 5 mtorr of Xe is due to two processes: (i) the ejection of photoelectrons by 1470-Å radiation imprisoned in the reaction vessel and (ii) the ejection of electrons from the gold electrode by the $6S[3/2]^0_1$ (8.44 ev) and $6S[3/2]^0_2$ (8.31 ev) excited states of xenon. Radiation imprisonment increases the effective lifetime of the $6S[3/2]^0_1$ state so that it can be collisionally deactivated to the metastable $6S[3/2]^0_2$ state as well as eject electrons from the gold surface. Due to the strong resonance absorption (*2*), a greater fraction of the excited atoms is produced closer to the LiF window as the pressure is increased. Consequently deactivation of the excited atoms by collision with the vessel wall near the window becomes increasingly important, so that the rate of electron ejection from the gold surface decreases as the pressure of xenon increases above 5 mtorr.

Figure 1*b* is a plot of the ratio $i_n/i(\mathrm{Xe})$ as a function of pressure of H_2, He, and N_2. The quantity $i(\mathrm{Xe})$ is the current obtained when 5 mtorr of Xe alone is irradiated by the resonance lamp and i_n is the current observed when gas n at pressure P_n is added to the Xe. Both He and H_2 decrease the current signal monotonically as the pressure is increased, whereas the addition of N_2 results in a signal increase, with a broad maximum at about 100 mtorr. No significant current above the background photoelectric effect is observed in the absence of the Xe.

Since H_2, He, and N_2 are all transparent at 1470-Å radiation they have no direct effect on the 1470-Å photons trapped in the reaction vessel. Figure 1*b* shows that H_2 is a more effective quenching agent than He. This is probably due to a contribution by the process (*3*): $\mathrm{Xe}^* + H_2 \longrightarrow 2\mathrm{H} + \mathrm{Xe}$, where Xe* is the activated state of Xe. The repulsive $^3\Sigma$ state of H_2 is 6 to 8 volts above the ground state and is readily excited by collision with either a $6S[3/2]^0_1$ or a $6S[3/2]^0_2$ xenon atom.

The increase of the $i_n/i(\mathrm{Xe})$ ratio upon the addition of nitrogen can only be accounted for by collisional excitation to one or more of the several metastable states (*4*) of N_2 lying below 8.44 ev. These excited N_2 molecules can diffuse to the gold surface and eject electrons The deactivation of these states by other N_2 molecules has been shown to be inefficient (*5*), so that the broad maximum observed in Fig. 1*b* is reasonable.

Thus xenon atoms excited by 1470-Å radiation are quenched more efficiently by H_2 than by He. Nitrogen, on the other hand, is capable of collisional excitation to one or more of several possible metastable states which are detected by their ability to eject electrons from a gold surface.

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Fossil Bacteria in Pyrite

Abstract. *A considerable variety of bacteria and similar microorganisms are present as preserved remains in pyrite samples of Pennsylvanian age obtained from the coal measures of southeastern Ohio. The types observed are similar to the present-day microflora found in stagnant pools of low oxygen and nutrient content.*

Various pyrite-containing samples from the Pennsylvanian and Mississippian coal formations of southeastern Ohio were collected as part of a study of the origin of acid mine drainage. Fossil bacteria were accidentally discovered in samples from Middle Kittanning (No. 6) Coal from northeastern Vinton County, Ohio. Other workers (*1*) have emphasized the improbability of finding identifiable bacterial remains in ancient sediments. It now appears that with electron microscopy much more evidence may be disclosed than was previously thought to exist.