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Commentary on Viewpoint "Heliox, nitrox, and trimix diving; hyperbaric oxygen treatment; and a flaw in Henry's law

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TO THE EDITOR: Henry's law is to dissolved gases what the Ideal Gas Law is to free gases. Arieli's Viewpoint (1) reminds that gas solubilities are not linear functions of ambient pressure across all mixture and temperature regimens. Even for monosolutes in solvents, Henry's law *only* holds at, or below, 1 atm, although often extended to all pressures without license. At 1 atm, changes in solubility coefficients with temperature are measured and theorized for many (single species) solute-solvent systems by linking reaction rate coefficients to an inverse exponential dependence on activation energy divided by temperature (Arrhenius rate law). The sign of the activation energy determines the temperature dependence of the solubility. For dissolved gases, activation energy is positive, and solubility decreases with increasing temperature. In the absence of chemical reactions and structure changes in both solute and solvent, gas solubility increases with pressure. But with changes in activation energy, chemical reactivity, and most importantly, solute-solvent structure, all bets are off. Above 1 atm, with multiple solutes and solvents including water, not much is known, measured, nor theorized. So at Los Alamos National Laboratory, we are performing molecular dynamics simulations for multigas systems (trimix, heliox, and nitrox).

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On Arieli's query about reduced solubility and risk for mixed gas diving, consider a recorded open-circuit trimix dive (C & C Team, RGBM Data Bank) baseline and two hypothetical dives for comparison. Baseline dive is 10/40 trimix (0.10 O_2, 0.40 He, 0.50 N_2) to 300 feet of seawater (fsw) for 15 min, with a switch to EAN50 (0.50 O_2, 0.50 N_2) at 70 fsw, and pure O_2 at 20 fsw. Second is same, with helium solubility reduced by 15%, and third is same, with nitrogen and helium solubilities reduced by 15%. Dive profiles were computed with deep stop LANL software (2, 3) calibrated against 2,800+ mixed gas, decompression profiles in the RGBM Data Bank (19 cases of decompression sickness). Risk function (4) is bubble volume inflation rate integrated over time. Total run times (bottom plus deco) are 94.5, 78.0, 63.5 min, and risks also decrease as 5.8, 4.9, 3.4% (contact me for profile information). Thus 15% reduction in gas solubilities leads to 30% reduction in dive run time and estimated risk.

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