Exposure to a moist environment degrades the fatigue resistance of all aluminum alloys, broadly attributed to hydrogen embrittlement, and introduces complex time-cycle dependent cracking behavior. This problem has been recognized for 100 years; however, alloy development, performance prognosis, and fundamental mechanism studies have not adequately addressed this damage mode. The importance of environment is demonstrated for fatigue crack initiation and propagation in precipitation hardened aluminum alloys. Modern methods to optimize resistance to such cracking are summarized, including: (a) fracture mechanics simulation of the effect of precorrosion on fatigue life, (b) environment exposure and process-rate limited modeling of crack growth kinetics, (c) high resolution experimental probes (such as SEM/EBSD and FIB/TEM) to characterize damage mechanisms, and (d) smart-ion inhibition of hydrogen uptake. These results show that there is much more to understanding and modeling fatigue than suggested by dislocation plasticity or continuum fracture mechanics approaches that dominate the field. From the environmental perspective, new opportunities for advances are apparent and tools are emerging to substantially improve alloy fatigue resistance.

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