Unraveling mechanisms of filler reinforcement with *in-situ* x-ray photon correlation spectroscopy

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The interfacial chemistry between elastomer matrix and reinforcing filler are key for the design of reinforced rubbers which meet goals for both performance and sustainability. Despite the broad commercial utility of reinforced rubbers to technologies such as tires, the crucial connections between chemistry at the elastomer/filler interface and the resulting mechanical properties at the macroscale remain poorly understood. We have elucidated, using X-ray photon correlation spectroscopy (XPCS), important relationships between the chemistry at the silica surface and the microdynamics of filler particles when the interfaces are modified by silane coupling agents. We have performed XPCS on silica-filled styrene-butadiene rubber (SBR) containing different silane coupling agents under both static strain and dynamic strain. Static strain (stress relaxation) XPCS measurements reveal differences in the disaggregation and subsequent ballistic motion of filler structures. Meanwhile, dynamic strain XPCS measurements allow us to probe the microscale breakdown and reformation of the filler network, which are responsible for the fuel efficiency and traction of tire tread compounds. From these experiments we have drawn connections between filler microdynamics and mechanical performance which provide new perspectives for understanding how the chemistry at the elastomer/filler interface give rise to the remarkable properties of reinforced rubbers.