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Violent Reactions from Non-Shock Stimuli

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Most reactions are thermally initiated, whether from direct heating or dissipation of energy from mechanical, shock, or electrical stimuli. For other than prompt shock initiation, the reaction must be able to spread through porosity or over large surface area to become more violent than just rupturing any confinement. While burning rates are important, high-strain mechanical properties are nearly so, either by reducing existing porosity or generating additional surface area through fracture. The first example is deflagration-to-detonation transition (DDT) in porous beds. During the early stages, weak compressive waves ahead of the convective ignition front will reduce porosity, thereby restricting the spread of combustion and the pressure buildup. If, however, pressure increases faster than can be relieved by loss of confinement, coalescing compressive waves can initiate reaction at hot spots from rapid pore collapse. This compressive reaction can drive a shockwave that transits to detonation, the most violent reaction in any scenario. It has been shown that reaction violence is reduced in DDT experiments if the binder is softened, either by raising the initial temperature or adding a solvent. An example of the role of mechanical properties in enhancing reaction violence through fracturing occurs when cavities in projectile fills collapse during acceleration in the gun barrel, which is referred to as setback. Explosives with soft rubber binders will deform and undergo mild reaction from shear heating within the explosive and adiabatic compression of any gas in the cavity. Stiff explosives are similarly ignited, but also fracture and generate additional surface area for a violent event. The last example to be considered is slow cook-off, where thermal damage can increase burning rate as well as provide porosity to enhance the pressure buildup. As reaction spreads from the zone of thermal run-away, an explosive binder that resists breakup will limit the violence.