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In order to improve the understanding of the burning efficiency and its observed size dependency of in-situ burning of crude oil on water, the vaporization order of the components in crude oils was studied. The vaporization order of such multicomponent fuels was assessed by studying the surface temperature, flame height, burning rate and burn residues of three alkanes (n-octane, dodecane and hexadecane), a mixture of these alkanes (1:1:1 volumetric ratio) and two crude oils (light and medium-light crudes). The experimental results were compared to four models for the vaporization order of multicomponent fuels. The alkanes were tested as benchmark fuels with a uniform vaporization order, for which all components evaporate simultaneously. As expected, these pure fuels showed a steady state burning with a near-constant surface temperature, flame height and burning rate. The alkane mixture showed similar steady state results but became dominated by the heaviest component towards the end of the burning. These results indicate that the lightest components had been depleted from the mixture. A near-uniform vaporization order in which the lighter components evaporate preferably best matched these results. The crude oils did not show any steady state behavior, but instead had an increasing surface temperature and decreasing burning rate and flame height, indicating a volatility controlled vaporization order. An increasing concentration gradient from the medium to heavy fraction in the burn residues furthermore showed that the vaporization was diffusion-limited. Analysis of the heat transfer balance for the crude oils indicated that the energy available for evaporation decreased over time due to increasing heat losses, which were caused by the volatility controlled vaporization order. Presumably, larger scale fires can overcome these heat losses, as they typically have higher burning rates, which increase the heat feedback to the fuel surface and therefore can result in the higher burning efficiencies.

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