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# Entropy-Aware Design of Arrhenius Reactive Nanofluid Flow Over a Moving Wedge

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## ABSTRACT

This article presents an entropy-aware design framework for an Arrhenius-reactive nanofluid flowing over a moving wedge embedded in a porous medium. The model couples Buongiorno nanoparticle transport (Brownian diffusion and thermophoresis), Rosseland thermal radiation, Darcy resistance, and temperature-sensitive Arrhenius chemistry. Governing equations are reduced by similarity transformation and solved with a Chebyshev spectral-collocation solver augmented by pseudo-arclength continuation to resolve stiff reaction terms and capture ignition/extinction bifurcations. Total entropy production is decomposed into thermal/radiative, viscous/porous, diffusive and chemical-irreversibility contributions and used as an explicit design objective alongside conversion.
Key results show S-shaped multiplicity with well-defined ignition and extinction thresholds; ignited branches have substantially higher temperatures and chemical irreversibility. Entropy budgets shift from thermal/diffusive dominance in extinguished states to chemical and viscous dominance in ignited states. Parametric sweeps reveal that modest changes in nanoparticle transport (Brownian and thermophoretic coefficients) reallocate entropy more effectively than comparable modifications of reaction intensity or wedge geometry. Multi-objective optimization (NSGA-II) produces Pareto fronts with a pronounced knee: knee-region operating points offer the best practical trade-off between conversion and second-law losses. Operating windows identify stable corridors that avoid fold neighborhoods and inform robust design choices.

Conclusions recommend prioritizing nanofluid transport control and Pareto-knee operation, combined with targeted thermal management to expand low-entropy feasible regions. The article notes limitations—Rosseland linearization for moderate $\Delta T$ and steady-state stability assessments—and recommends mapping dimensionless groups to experimental systems and performing time-dependent stability studies for practical translation.

***Keywords:*** *Arrhenius Reactive Nanofluid, Entropy Generation, Moving Wedge Flow, Buongiorno Model, Thermophoresis and Brownian Motion, Ignition–Extinction Bifurcation, Porous Medium, Thermal Radiation, Multi-Objective Optimization, Pareto Analysis.*