# Resonance Catalysis Briefing

Date: September 24, 2025

Goal  
To demonstrate and harness a new class of chemical reactivity, resonance-driven catalysis, where latent vibrational energy in CO2 and H2O is coherently activated into hydrocarbon formation.

This approach follows a two-track strategy:

* Track A (Proof of Concept): Rigorous lab-scale validation with advanced spectroscopy, isotope tracing, and high-Q resonators.
* Track B (Practical Downshift): Translate validated principles into accessible, low-cost systems that anyone can build, similar to how solar panels evolved from lab prototypes to household devices.

## Scientific Foundation (Track A)

### The Hypothesis

Conventional catalysis relies on thermal or electrochemical driving forces. Our framework proposes a third pathway:

* Resonant coupling between IR-active vibrational modes of CO2 (~2350 cm^-1) and H2O (~3400 cm^-1, 1640 cm^-1).
* Geometric resonance structures (metalloporphyrins, metamaterial antennas, phononic crystals) phase-lock these vibrations.
* Latent → active energy conversion: Coherent alignment lowers activation thresholds, enabling otherwise disfavored CO2 → hydrocarbon reactions.

### Critical Validation Tasks

1. Spectroscopic confirmation: Detect resonance enhancement at CO2/H2O bands.
2. Isotopic tracing (13CO2, D2O): Verify incorporation into products.
3. On/off resonance control: Demonstrate rate enhancement disappears when geometry is detuned.
4. Cryogenic/pulsed tests: Mitigate decoherence and isolate coherent effects.

### Resources

* Estimated budget: $50K for mid-IR sources, cryogenics, mass spectrometry.
* Target collaborators: energy catalysis labs (e.g., Jaramillo Group, Stanford).

## Engineering Application (Track B)

### Simplified Prototype Design

The same physics can be expressed in household-scale devices:

1. Resonant Surface
   * Etched copper/aluminum foil with fractal/antenna geometries.
   * PCB-level fabrication (<$50).
2. IR Photon Source
   * Mid-IR LEDs tuned to 2.7 μm (H2O) and 4.3 μm (CO2).
   * Off-the-shelf components (<$100).
3. Reaction Environment
   * Humid CO2 chamber (e.g., soda bottle + vinegar/baking soda).
   * Thin water film or hydrogel matrix.
4. Detection
   * Basic sensors: handheld fuel-cell detectors, gas sniffer kits.
   * Low-cost alternative to GC/MS for initial proof.

### Key Equation (Simplified)

M\_active ≈ f(R ⋅ P\_IR ⋅ G\_geom)

* R: Resonance quality (geometry match)
* P\_IR: Photon flux (LED power)
* G\_geom: Overlap factor of reactants at active surface

## Pathway to Democratization

* Once resonance effect is validated (Track A), the design can be open-sourced as a citizen-lab kit.
* Goal: distributed energy devices that bypass industrial bottlenecks.
* Even at milliwatt yields, a working prototype would establish a new physics of catalysis.

## Impact

* Scientific: Establishes resonance-driven chemistry as a legitimate third pillar alongside thermal and electrochemical methods.
* Technological: Creates foundation for hydrocarbon synthesis and energy harvesting using only light, water, and CO2.
* Societal: Democratizes access to energy experiments, enabling innovation outside centralized industry.