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Ecometachip-Mini

A Low-Cost, Eco-Friendly Chemical Identifier Utilizing a Novel Coir-Rubber Dielectric Sensor

Abstract

This paper presents the Eco-MetaChip Mini, a novel, low-cost, and eco-friendly system for the preliminary identification of common liquids based on changes in their relative permittivity (ϵ_r) using a novel rubber coir material.

Authors : Abhiram B, Aaromal A, Devanarayanan CR, Ivana Anto

Affiliation : School of Engineering, CUSAT (Kerala, India)

The problem

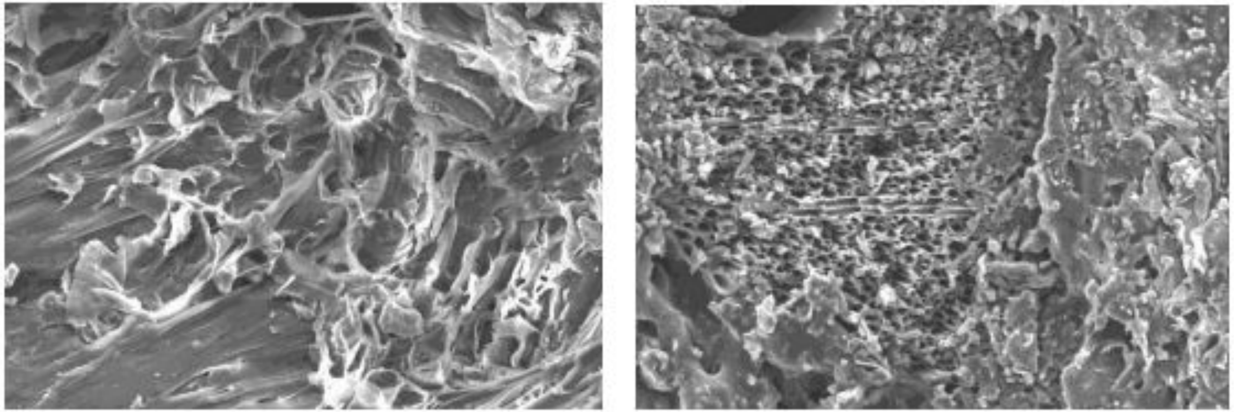
Benchtop FT-IR Spectrometers (current)

Need for low-cost, biodegradable sensing for field analysis

Materials Required

Component	Specification
Power Source	3 V CR2032 cell
Sensing Element	30 mm×30 mm×2 mm Coir-Rubber Patch
Oscillator Frequency (f_o)	≈100 MHz
Toroidal Inductor (L1)	15 Turns, 8 mm OD, 54nH
Oscillator Capacitor (C1)	47 pF NPO Ceramic
Oscillator/Driver (Q1, Q2)	2N3904 NPN Transistor
Rectifier Diodes (D1–D4)	1N4148 Silicon Diodes (4 ns recovery)
Filter Capacitor	100 μF Electrolytic
Output LED Resistors	1 kΩ (R5, R6, R7)

The Novel Material

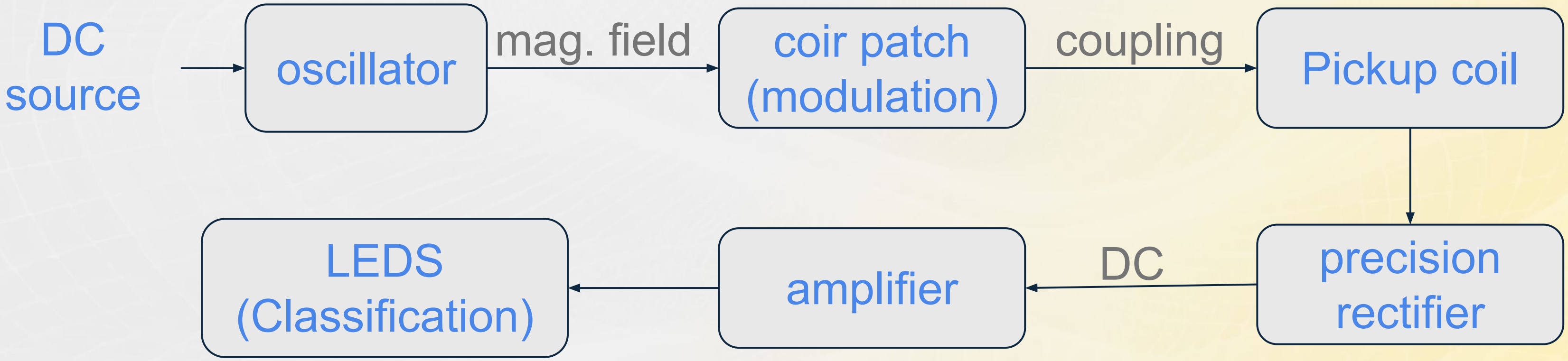


(a) (b)

Scanning electron microscopy of (a) CoR and (b) CoRC.

Coir-Rubber Composite: Porous matrix allows liquid integration

System Architecture



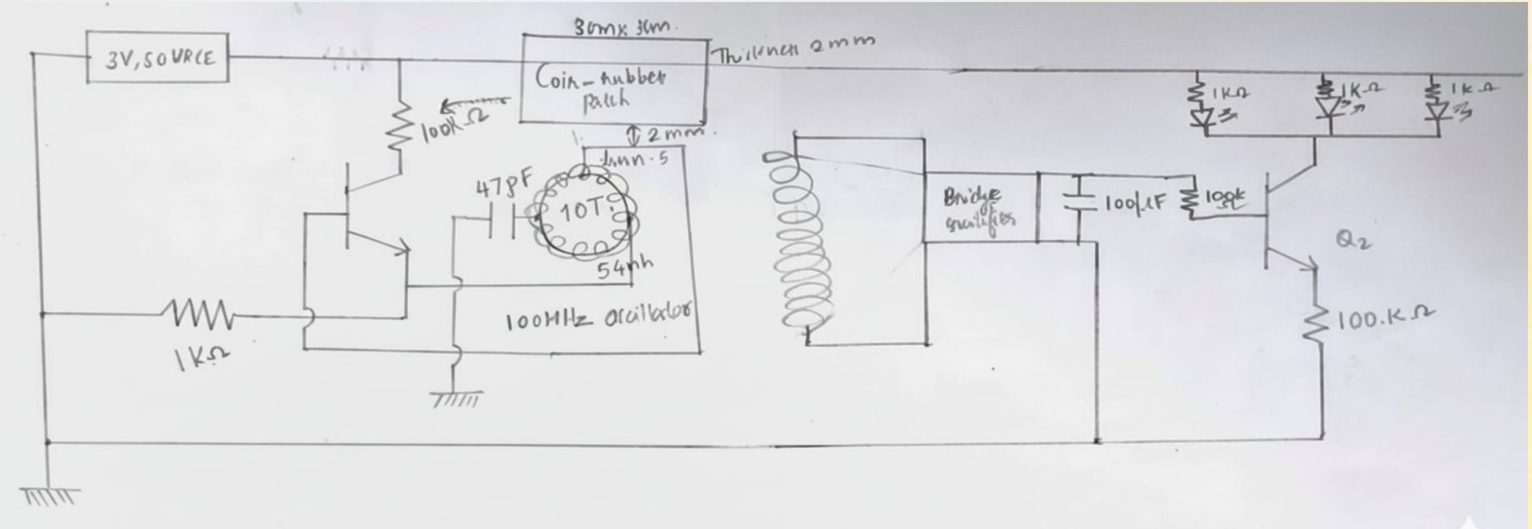
100 MHz Hartley Oscillator coupled with dielectric resonator

Methodology/Physics (Dielectric Loading)

$$f_o \propto 1/\sqrt{LC}$$

Liquid permittivity alters capacitance, modulating magnetic field amplitude

Circuit Implementation



Fast-recovery diodes rectify RF signals to DC voltage

Addressing Signal Loss

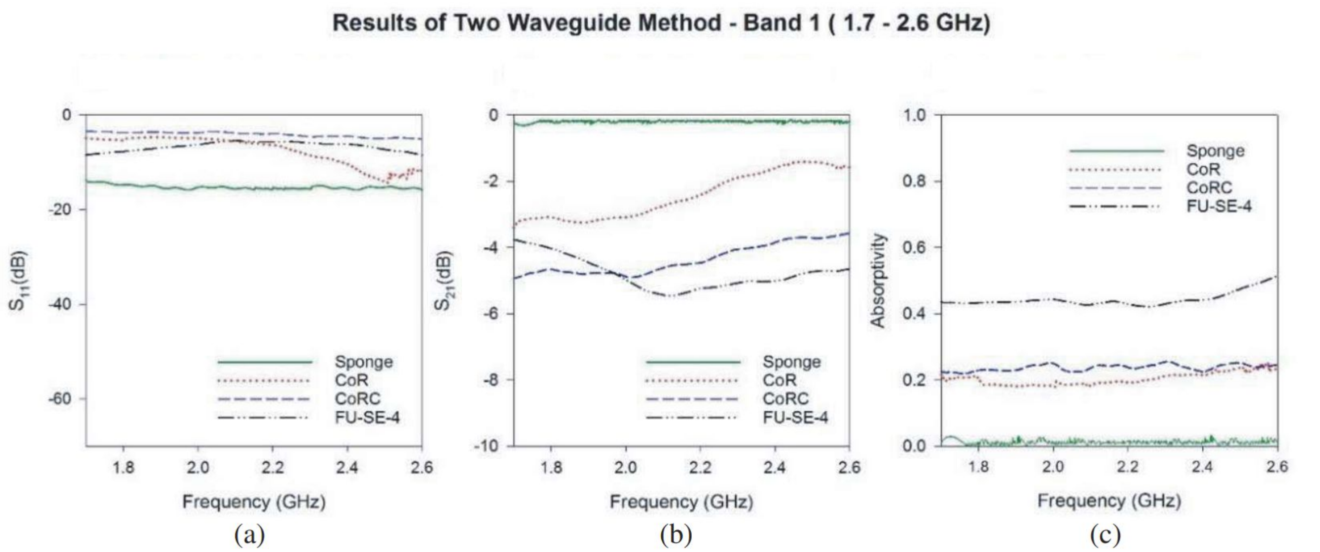


Figure 6. (a) Reflection, (b) transmission and (c) absorption Characteristics of absorbers with thickness = 6 mm.

Carbon content optimized for coupling, not just absorption

Experimental Results

Liquid Sample	Approx. ϵ_r	Measured V_{DC} (mV)	Observed LED State
Air (Baseline)	1.0	45 mV	None
Petrol (≈ Hexane)	≈1.9	70 mV	Very Dim Red
Acetone	≈21	135 mV	Bright Red
Ethanol	≈24	190 mV	Red and Green
Deionized Water	≈80	260 mV	Red, Green, and Blue

Higher permittivity liquids generate significantly higher output voltages.

Visual Classification

$$V_{\mathrm{DC}} \propto \Delta\epsilon_r \propto \text{Number of Illuminated LEDs}$$

Three-level LED output based on voltage thresholds.

Conclusion & References

Eco-friendly, low-power solution for real-time liquid analysis

[1] Prof. Dr. Anju Pradeep, et al., "Frequency Selective Absorber using an Innovative Arrangement of Coir and Rubber," Indian Patent No. 489405, granted 2022.

[2] R. D. Lide, Ed., *CRC Handbook of Chemistry and Physics*, 89th ed. Boca Raton, FL: CRC Press, 2008.

[3] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.