



ElectroCool® Dielectric Coolants

High Frequency Electrical Characteristics

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Engineered Fluids'

ElectroCool Dielectric Coolants:

- ElectroCool Dielectric Coolants are synthetic Dielectric Coolant Fluids, designed specifically for immersion cooling of electronics.
- ElectroCool Coolants have been used since 2017 in tens of thousands of applications, with a perfect safety record.
- ElectroCool Coolants are tested and Guaranteed for Material Compatibility with thousands of materials



About ElectroCool Dielectric Coolants:

- ElectroCool Dielectric Coolants are manufactured in Engineered Fluids' ISO 9001-Certified Manufacturing Facility in Texas, USA. They are standardized, thoroughly tested and guaranteed.
- ElectroCool Dielectric Coolants are classified as "Fire Resistant", "Non-Propagating" and "Self Extinguishing"
- ElectroCool Dielectric Coolants are biodegradable, nontoxic, non-halogenated, Food Grade and 100% ozone safe. ElectroCool products have no sulfur, metals, or PFAS compounds.



High Frequency Electrical Characteristics: Dielectric Constant (D_k)

Dielectric Constant (Relative Permittivity) Measures a material's ability to store AC electrical energy in an electric field. In circuit design, matching components with similar dielectric constants is essential. RF and Microwave Circuits use materials with dielectric constants less than 4.0

Transitioning from air cooling to liquid immersion requires coolant fluids with low dielectric constants, similar to air, to maintain compatibility with existing designs.

Dielectric Constant of Common Dielectric Materials	
Air	1.00058
PTFE	2.0-2.1
HDPE Polyethylene	2.26

High Frequency Electrical Characteristics: Dielectric Constant (D_k)

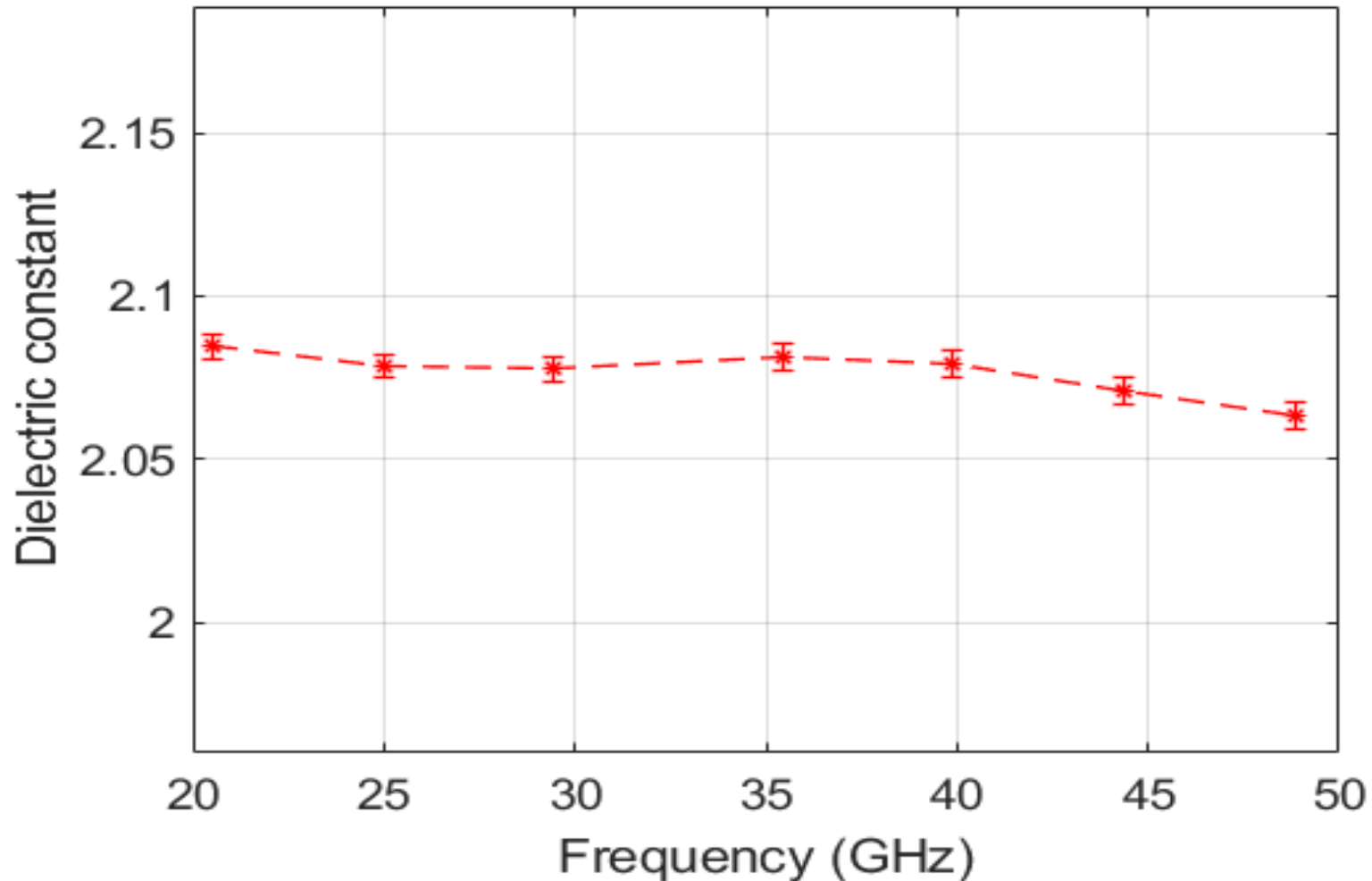
The test results are in agreement with a Debye-like dielectric relaxation model, decreasing from 2.3 to 2.06. All measurements made at 25C:

Frequency	Dielectric Constant
60 Hz	2.30
1.3 GHz	2.28
2.4 GHz	2.24
5.1 GHz	2.17
20.5 GHz	2.08
24.9 GHz	2.08
29.4 GHz	2.08
35.4 GHz	2.08
39.9 GHz	2.08
44.3 GHz	2.07
48.8 GHz	2.06



High Frequency Electrical Characteristics: Dielectric Constant (D_k)

In the measured frequency range, D_k values are almost linear.



High Frequency Electrical Characteristics: Dissipation Factor

- The Dissipation Factor is a measure of how much energy is lost to heat when electromagnetic waves pass through a material. This energy that's lost to heat is a loss of the signal.
- To minimize signal losses at microwave frequencies, it's important that dissipation factors of all components be very low and predictable across the intended frequency range.
- Dissipation Factor is sometimes called "loss tangent" or " $\tan-\delta$ "





High Frequency Electrical Characteristics: Dissipation Factor

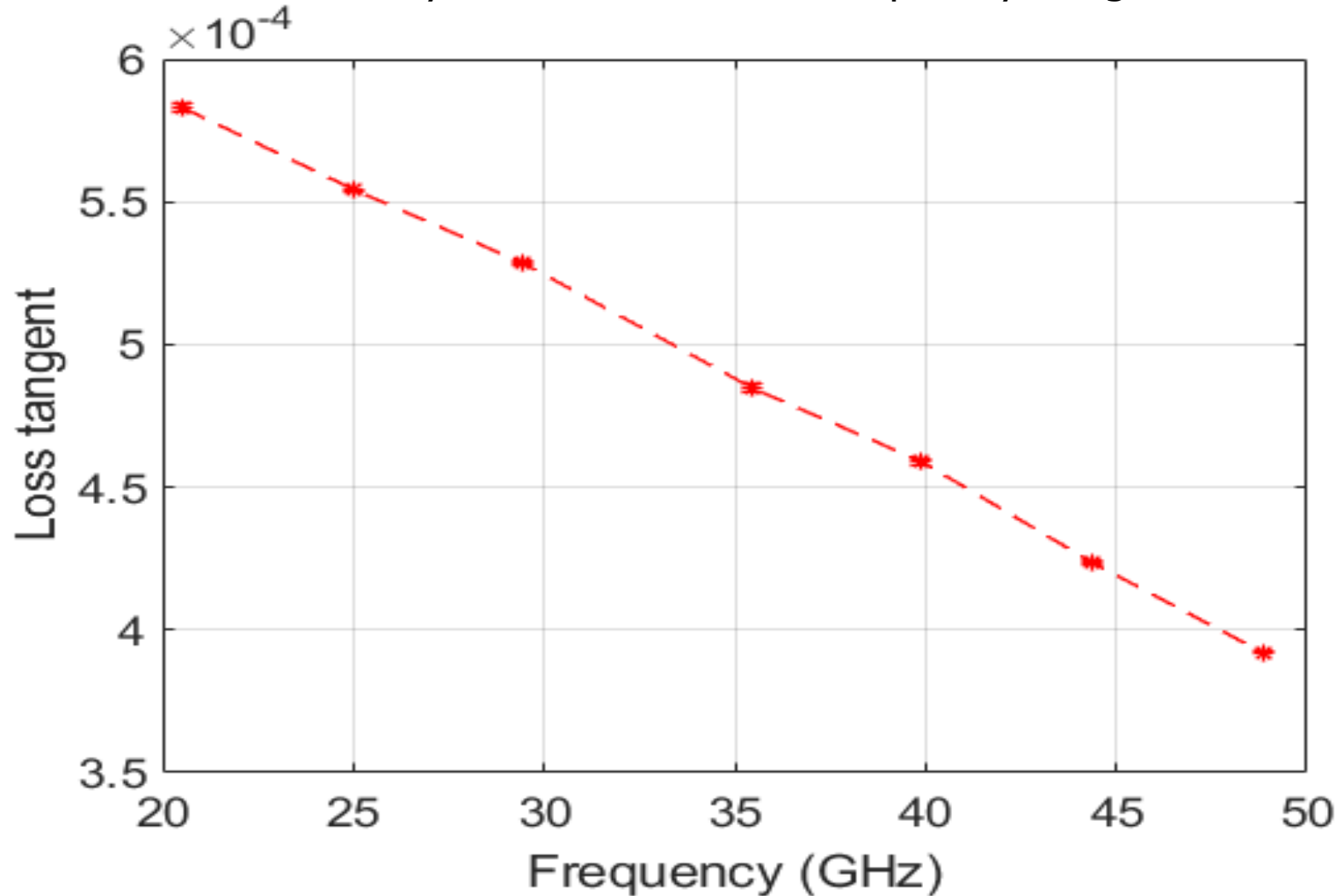
Engineered Fluids has measured the dissipation factor of ElectroCool EC-110 at various frequencies. All measurements made at 25C:

Frequency	Dissipation Factor (X 10 ⁴)
60 Hz	5.66
1.3 GHz	5.75
2.4 GHz	5.94
5.1 GHz	6.21
20.5 GHz	5.83
24.9 GHz	5.54
29.4 GHz	5.29
35.4 GHz	4.85
39.9 GHz	4.59
44.3 GHz	4.24
48.8 GHz	3.92



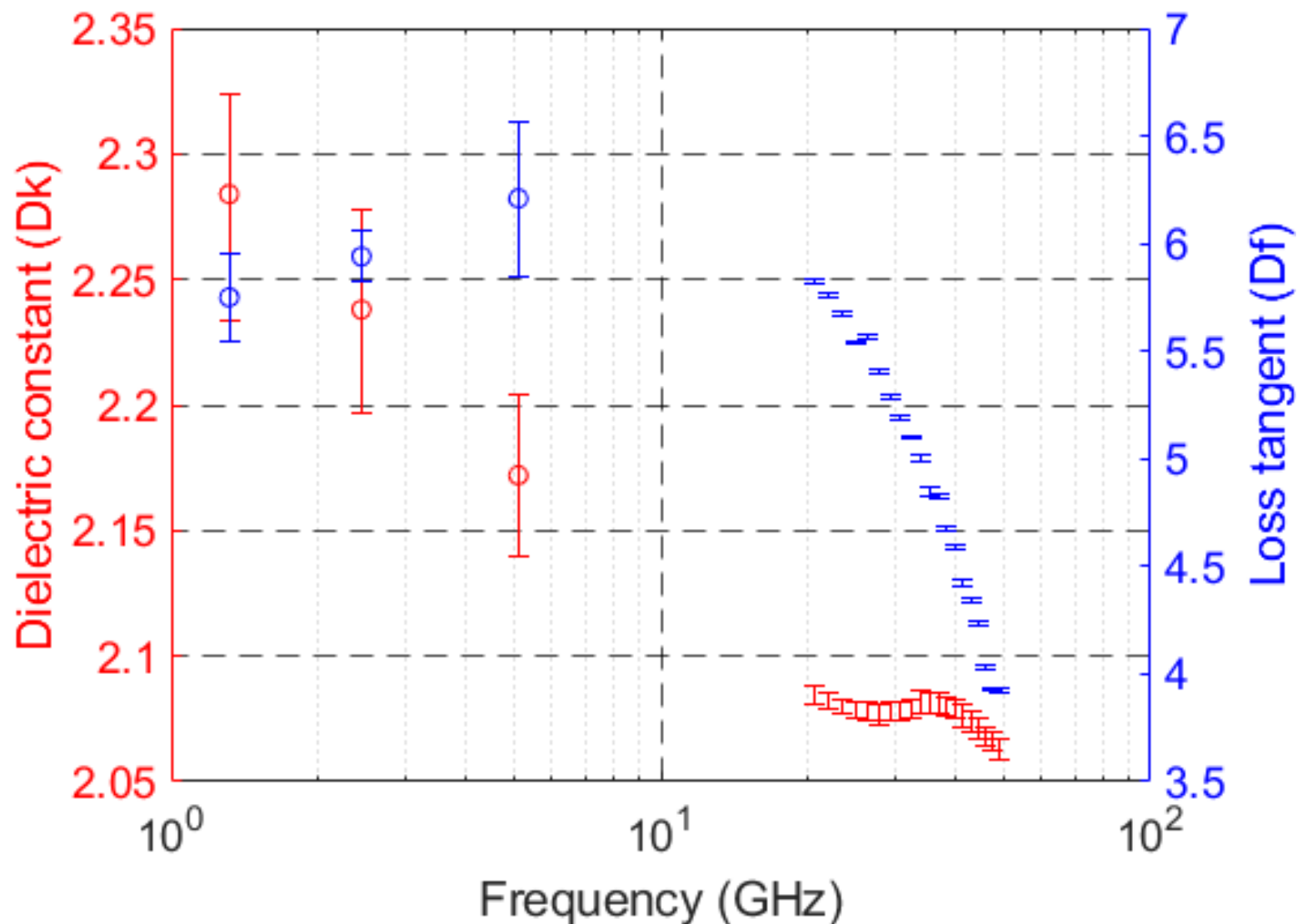
High Frequency Electrical Characteristics: Dissipation Factor

ElectroCool exhibits extremely low losses in the frequency range 25-50 GHz.





High Frequency Electrical Characteristics: Summary:



High Frequency Electrical Characteristics: Summary:

- ElectroCool Dielectric Coolants exhibit extremely low losses at frequencies to 50 GHz. The Dissipation Factor decreased from $6e-4$ to $4e-4$.
- The Dielectric Constant of ElectroCool Coolants is very low and similar to that of other PCB components. Through the measured range the Dielectric Constant decreased from 2.085 to 2.065.



In Addition:

- ElectroCool Dielectric Coolants are the only coolants with a 10-year Operating Life Guarantee.
- ElectroCool Dielectric Coolants are the only coolants with a Material Compatibility Guarantee
- ElectroCool Coolants are the only coolants with EF's Free Laboratory Analysis Program®
- ElectroCool Dielectric Coolants are the only coolants with Engineered Fluids' Coolant Recycling Program®.



Engineered Fluids, Inc.– Coolant Product Portfolio

High-Performance, Environmentally benign, Non-Corrosive Dielectric Coolants

ElectroCool®- Dielectric Immersion Coolants for Semiconductors and Servers

- Server / CPU / GPU / SSD / DRAM
- Lasers / LEDs / RF Amplifiers / Tubes / Processors / RADAR
- Battery / Fuel Cell cooling for Power Generation (Solar / Wind / Conventional) in stationary electrical storage applications

AmpCool®- Dielectric Immersion Coolants for Batteries, Electric Motors and Hydraulics

- Electric motors & motor controllers
- Hydraulic power transmission and actuator systems
- Aquatic applications for pressure compensating, insulating, and lubrication
- Battery and Fuel Cell cooling in hybrid and electric vehicles

SubmergeDeep®- Non-Compressible Pressure Compensation Fluids for Submarine Application

- Dielectric Coolants for Thermal Management of Submarine electronics and batteries
- Highly Biodegradable, Non-Toxic for Marine Application

Dielectric Solvents – Safe and Effective Removal of Grease, Dielectric Fluids and Mineral Oils

- Fully dielectric solvents for use with all electronics and immersion cooling systems
- Food Grade and Non-Food Grade Types Available



For more information...

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