# Pale Blue

# Simple and easy-handling propulsion system using water as a propellant

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#### What We Do?

- Pale Blue provides water propulsion systems for SmallSats & NanoSats
- Founded in 2020 as the University of Tokyo spinoff company



 Design, build & test propulsion systems inhouse





### **Propulsion System**







CubeSat Propulsion System Low cost High cost Simple Complicated Easy to handle Handling issue Robust in attitude/orbit Not robust in attitude/orbit

> Not suitable for CubeSat concept



CubeSat Propulsion System
Low cost
Simple
Easy to handle
Robust in attitude/orbit
Propulsion System
High cost
Complicated
Handling issue
Not robust in attitude/orbit

Water Propulsion System



Propulsion	Storage	Density g/cm <sup>3</sup>	Propulsion System
Ammonia	Liquid (1.16 MPa)	0.565	Resistojet / Mono-Propellant / Bi-Propellant
Argon	Pressurized Gas	-	Cold-gas Jet / Resistojet
Butane	Liquid (0.21 MPa)	0.6	Cold-gas Jet / Resistojet
Nitrous Oxide	Pressurized Gas	0.913	Bi-Propellant
Hydrazine	Liquid	1.013	Resistojet / Mono-Propellant / Bi-Propellant
Hydrogen peroxide*	Liquid	1.45	Mono-Propellant / Bi-Propellant
Indium	Solid	7.31	FEEP (Field Emission Electric Propulsion)
lodine	Solid	4.93	Ion Thruster / Hall Effect Thruster
Nitrogen	Pressurized Gas	-	Cold-gas Jet / Resistojet
PTFE	Solid	2.2	Pulsed Plasma Thruster
R236fa	Liquid (0.27 MPa)	1.36	Cold-gas Jet / Resistojet
Water	Liquid	1.00	Resistojet / Ion Thruster / Hall Effect Thruster
Xenon	Pressurized Gas	1.1 (5.8 Mpa)	Gridded Ion Thruster / Hall Effect Thruster



Propellant	Physical	Health	Environmental
Ammonia	2	5	0
Argon	1	0	0
Butane	2	1	0
Nitrous Oxide	2	3	0
Hydrazine	1	9	1
Hydrogen peroxide*	1	6	0
Indium	-	_	-
lodine	1	6	1
Nitrogen	1	0	0
PTFE	0	0	0
R236fa	1	1	0
Water	1	0	0
Xenon	1	0	0



System Name	PBR-10
Propellant	Water
Volume	90 x 95 x 50 mm
Wet Mass	< 575 g
Total Impulse	> 55 Ns
Thrust (ave)	1.0 mN
Supply Voltage	7 V to 12.6 V
Ave. Power at Thrust	6 W
Peak Power	15 W
Command Interface	RS-422 UART
Storage Temperature	4 degC to 60 degC



### Water Resistojet Thrsuter – Test Result





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## Water Resistojet Thruster - Status

- The water resistojet thruster was already operated in space.
  - SPHERE-1 EYE (Sony Satellite)
  - Thrust was measured as the angular momentum of the satellite
- PBR-10 is being operated as technical demonstration
  - It will be reported soon.
- Three products are in the lineup.
  - PBR-10:0.5 U package
  - PBR-20:1 U package
  - PBR-50 : for 100 kg-class satellite
- Products were shipped to companies and universities.





System Name	PBI
Propellant	Water
Volume	98 x 98 x 110 mm
Wet Mass	< 2.0 kg
Total Impulse	> 7000 Ns
Thrust (ave)	> 0.35 mN
Supply Voltage	24 V to 34 V
Power at Thrust	< 60 W
Command Interface	RS-422 UART
Storage Temperature	-20 degC to 60 degC



#### Water Ion Thruster – Ground Operation Test Result



- Pale Blue provides water propulsion systems for SmallSats & NanoSats
- Propulsion system expands the possibility of CubeSats, but it's not suitable for the concept of CubeSats
- Water is a fascinate propellant in view of safety, cost, and ease of handling.
- Water resistojet thruster
  - Vaporized water is exhausted from the nozzle and generated the thrust
  - The thruster was packaged as "plug-and-play" in 0.5 U, 1U, and bigger one.
  - In-orbit demonstrations were conducted
  - Products are in the lineup
- Water ion thruster
  - Water plasma is accelerated by the high-voltage power source and generated thrust
  - The thruster was packaged in 1U+
  - In-orbit demonstration is planned in 2025



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