FlowRACS

Flow Cytometric Raman-activated Cell Sorter

Application Manual

Phylogeny

Catabolism

Species interaction

Anabolism

Stress/Drug response

Metabolite-interaction network



Functional Single Cells at Your Fingertips

eCyte

FlowRACS

Label-free, non-invasive, high-throughput flow-based sorting

FlowRACS is an advanced automated cell sorting system designed for capturing metabolic functional information at single-cell resolution. It efficiently isolates target cells through flow-based cell sorting within a microfluidic chip. Powered by Raman spectroscopy and dielectrophoretic sorting, FlowRACS delivers label-free, non-invasive cell sorting. It supports a wide range of applications, including microbiome research, cell factory screening, enzyme resource mining, plant molecular breeding, and mammalian cell profiling.



▲ The illustration above shows FlowRACS in operation

Simplified Sample Preparation

No labeling or staining needed

Broad Sample Applicability

Suitable for bacterial, archaeal, fungal cells, as well as microalgal, plant, animal, and human cells

High Throughput

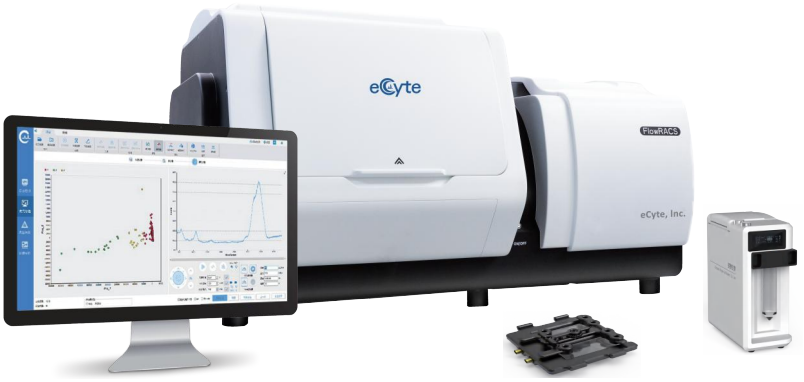
Cell analysis throughput up to 3,000 events/min and cell sorting throughput up to 2,000 events/min

High Cell Viability

Performs single-cell Raman spectrum acquisition and cell sorting in an aqueous environment, maximally preserving cell viability

Automated Intelligence

Automated instrument control and intelligent data analysis enable one-click automatic sorting based on the single-cell Raman spectrum of each cell



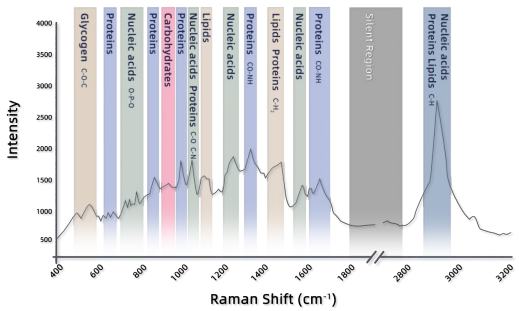
Control and analysis software Main Unit FlowRACS Chip and Chip Adapter Sample Injection

FlowRACS - Raman Spectroscopy

Unlabeled Biological Samples

Label-free, non-invasive cell detection enables "in situ" probing of cellular metabolic function

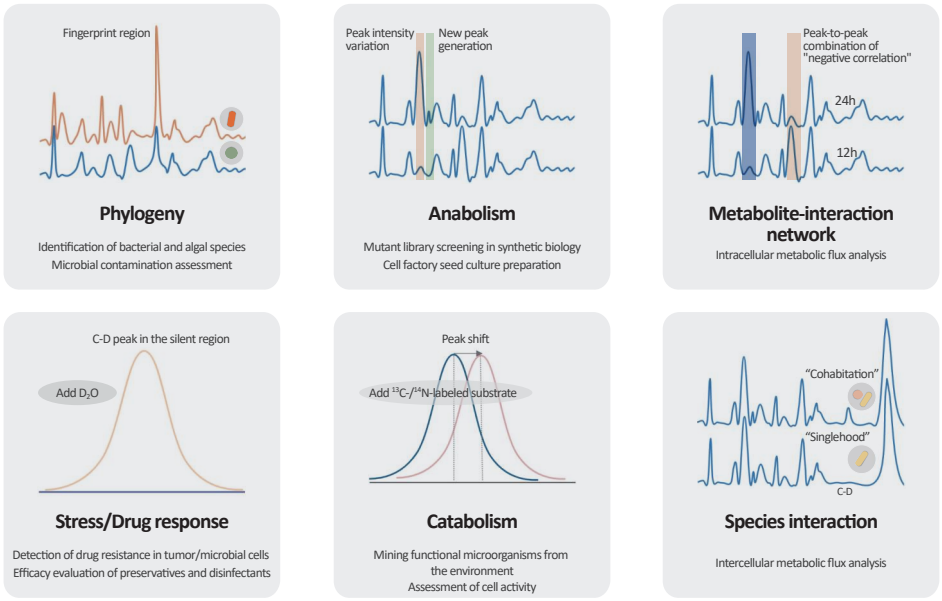
Single-cell Raman spectroscopy reveals metabolic phenotypes of cells in biological systems by measuring compositions of major cellular components such as proteins, nucleic acids, lipids, and carbohydrates in each cell. Each single-cell Raman spectrum consists of over 1,500 Raman peaks, with each peak corresponding to information from a specific chemical bond. Spectral analysis provides multidimensional information on cellular metabolite composition and abundance, enabling in situ measurement of the physiological states, phenotypes, and functions of individual cells.



- **Raman Spectroscopy:** Raman spectroscopy is a non-destructive, label-free scattering spectroscopy technology. It measures light wavelength changes during scattering resulting from the interaction with covalent bonds, revealing the chemical composition of the sample under analysis.

- Fingerprint region (400-1800 cm^{-1}): Informative for characterizing the composition and relative abundance of intracellular metabolites
- Silent region (1800-2700 cm^{-1}): Contains no distinctive Raman signals for natural biological samples
- High wavenumber region (2700-3200 cm^{-1}): Informative for characterizing C-H stretching vibrations in lipids and proteins

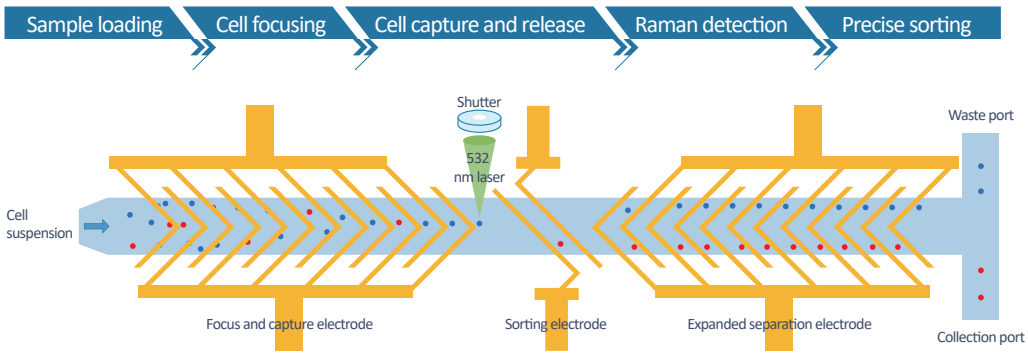
Panoramic Raman measurement reveals heterogeneity in single-cell metabolic function



- "Ramanome" refers to a collection of multiple single-cell Raman spectra gathered from a population of cells under specific conditions at a given time point. Each single-cell Raman spectrum characterizes many metabolic phenotypes of the cell in that state. Each Ramanome represents a "collective snapshot" of metabolic functions of cells in that state, enabling a panoramic characterization of metabolic function at the single-cell level.

FlowRACS - Cell Sorting

Cell Sorting Workflow



- **Core technology:** The innovative Positive Dielectrophoresis Induced Deterministic Lateral Displacement (pDEP-DLD) technology enables efficient identification and high-speed sorting of target cells.

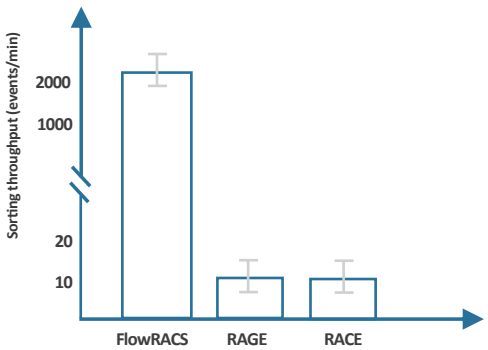
Efficient Cell Identification:

Leveraging the state-of-the-art pDEP-DLD technology and innovation in microfluidics, FlowRACS enables efficient focusing of cells within a wide-field channel. This capability empowers precise manipulation of individual cells even under high-speed flow conditions, leading to the acquisition of superior-quality Raman spectral data.

High-speed Cell Sorting:

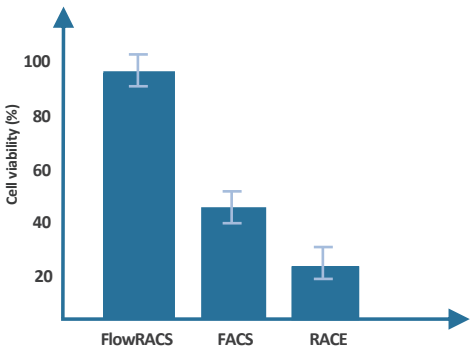
Thanks to the cutting-edge pDEP-DLD technology and microfluidic innovation, FlowRACS enables high-throughput and high-accuracy sorting of target cells. This is achieved through integration of an intelligent expert system for functional differentiation.

High-throughput intelligent discrimination enhances the efficiency of single-cell metabolic functional characterization and screening.



FlowRACS: pDEP-DLD technology-based continous-flow Raman-activated cell sorting
RAGE: Optical tweezers-based droplet sorting
RACE: Raman-activated cell ejection sorting

Obtains high-viability cells, which can be applied to downstream sequencing and culture



FlowRACS: pDEP-DLD technology-based continuous-flow Raman-activated cell sorting
FACS: Fluorescence-activated cell sorting
RACE: Raman-activated cell ejection sorting

FlowRACS - Data Analysis

The Cellight Studio software features diverse detection modes, real-time full-spectrum acquisition, intelligent data preprocessing, and visualized result presentation.

Cellight Studio is analysis software with automated system control and intelligent data analysis capabilities. It generates standardized experimental data through automatic calibration and Raman spectrum acquisition. By integrating artificial intelligence algorithms, it enables real-time online classification of cell types and cell functions, allowing high-quality cell screening.

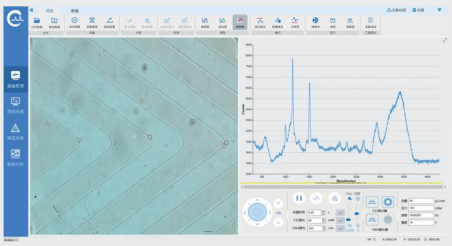
The Cellight Studio software includes predefined scenarios for quantitative and qualitative analyses, allowing users to effortlessly create customized sorting models with a single click.

The software uses intelligent algorithms to automate data quality control, data preprocessing, and model construction.

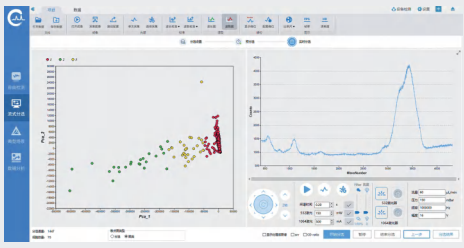
Workflow for the software

Model establishment → Real-time sorting → Data analysis and visualization of results

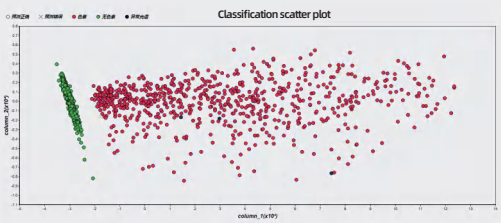
1 Set parameters to quickly establish a scenario model

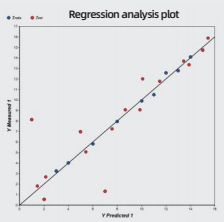


2 Start sorting and monitor cell distribution in real-time



3 Data analysis to derive qualitative and quantitative results





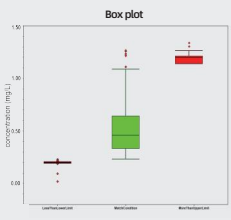


Fig 1. Cluster analysis of pigmented cells (red) and non-pigmented cells (green)

Fig 2. Training set is shown in blue, and test set is shown in red

Fig 3. The green boxes represent samples that fall within the threshold range

FlowRACS - Configuration and performance parameters

Sample Type	Suitable for bacterial, archaeal, and fungal cells, as well as microalgae, plant, animal, and human cells
Cell Size	1-40 μm
Initial Cell Input	10^2-10^4 cells/mL
Analysis Throughput	Up to 3,000 events/min
Sorting Throughput	Up to 2,000 events/min
Sorting Environment	Liquid phase
Sorting Mode	Flow cytometry, positive dielectrophoresis, Raman-activated cell sorting
Consumable	Flow-mode Raman-activated Cell Sorting/Assay Kit
Weight	120 kg
Instrument Size	1145 mm×770 mm×645 mm (L×W×H)
Power Supply	220 V±10%，50 Hz±5%，120 W

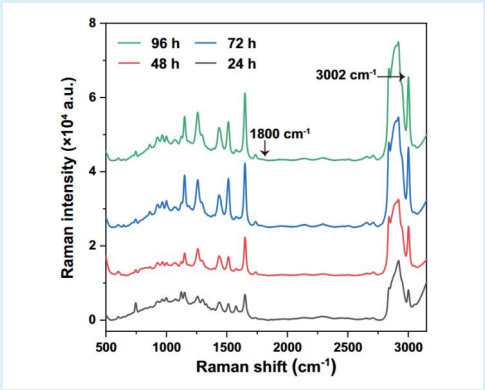
Cell Factory assessment in Synthetic Biology

Intracellular functional testing of biological components/Screening of high-yield strains/Screening of chassis cells

Application scenario: Screening of high DHA-producing Schizochytrium cells
Characteristics: Label-free quantitative analysis of target products

FlowRACS is an innovative instrument based on pDEP-RACS technology, offering label-free and non-destructive advantages. FlowRACS rapidly obtains various cellular metabolic phenotype information at both the population level and single-cell level, thereby optimizing industrial fermentation processes.

In this case, starting from over 100,000 cells, dozens of high-producing strains were successfully isolated. The best strain exhibited a 58% higher DHA yield than the wild type and a 12% higher yield than a strain previously developed over several years.



The averaged SCRS and distribution of "I_{3002}-I_{1800}" (positively correlated with DHA content)

- Wang X, et al., Label-free high-throughput live-cell sorting of genome-wide random mutagenesis libraries for metabolic traits by Raman flow cytometry. Proc Natl Acad Sci U S A. 2025.

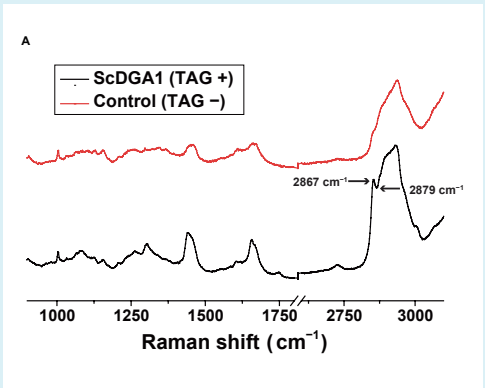
Enzyme Resource Mining

Screening of enzyme functional gene library

Application scenario: Screening of diacylglycerol acyltransferase (DGAT) gene library
Characteristics: "screen-first, culture-second" strategy

FlowRACS is an innovative instrument based on pDEP-RACS technology, offering label-free and non-destructive advantages, and supporting the sorting strategy of "screen-first, culture-second". It enables rapid functional identification of DGAT, addressing the time-consuming nature of traditional methods and providing a powerful tool for efficient enzyme component discovery.

In this case, using a candidate DGAT gene library derived from Nannochloropsis oceanica, only a 10-minute FlowRACS run resulted in the identification of three previously reported highly efficient genes and two less efficient genes that have not been reported before.



Characteristic peak associated with DGAT

- Wang X, et al., Positive dielectrophoresis-based Raman-activated droplet sorting for culture-free and label-free screening of enzyme function in vivo. Sci Adv. 2020.

Microbiome Study

Microbial resource mining/Gut microbiota research/Rapid antimicrobial susceptibility test

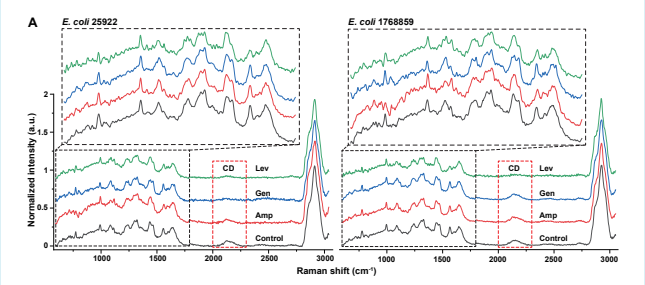
Application scenario: Antimicrobial susceptibility test

Characteristics: Culture-free, low-abundance drug-resistant cell identification

FlowRACS utilizes D2O-Ramanometry technology and combines advanced algorithms such as Raman Barcode of Cellular-response to Stress (RBCS), Intra-Ramanome Correlation Analysis (IRCA), and Ramanome machine learning. It achieves real-time determination of the drug stress status at the single-cell level, and constructs networks of intracellular metabolite interconversion, thereby revealing the mechanism of bacterial-drug interactions.

In this case, researchers improved the sampling depth of single-cell Raman spectra in antimicrobial susceptibility test, solving the problem of identifying drug-resistant cells that usually exist in very low proportions within the population.

- Wang X, et al., Robust Spontaneous Raman Flow Cytometry for Single-Cell Metabolic Phenome Profiling via pDEP-DLD-RFC. Adv Sci. 2023.
- Liu M, et al., Single-Cell Identification, Drug Susceptibility Test, and Whole-genome Sequencing of Helicobacter pylori Directly from Gastric Biopsy by Clinical Antimicrobial Susceptibility Test Ramanometry. Clin Chem. 2022.



Single-cell Raman spectra of bacteria under different drug

Applications

Microbiome Study

Microbial resource mining/Gut microbiota research/Rapid antimicrobial susceptibility test

Application scenario: Differentiation of various types of tumor cells

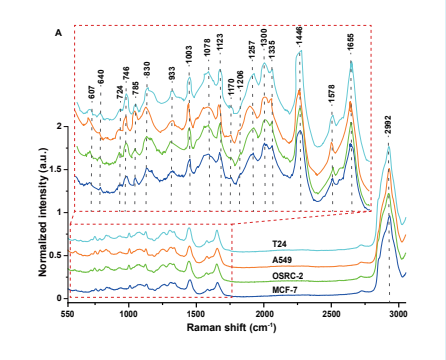
Characteristics: Accurate analysis of Raman spectral peaks

FlowRACS is an innovative instrument based on pDEP-RACS technology, offering label-free and non-destructive advantages.

It enables the acquisition of high-quality Raman spectrum (>1,000 peaks and combinations) for precise differentiation of various types of tumor cells. Additionally, it reveals the metabolic "heterogeneity" present among tumor cell populations.

In this case, researchers achieved a direct typing accuracy of over 90% for 4 types of tumor cells.

- Wang X, et al., Robust Spontaneous Raman Flow Cytometry for Single-Cell Metabolic Phenome Profiling via pDEP-DLD-RFC . Adv Sci. 2023.



Analysis of specific Raman peaks representing cell characteristics

Applications & References

- Using FlowRACS, the yield of lycopene in cells was directly quantified, revealing that carbon starvation induces the differentiation of Saccharomyces cerevisiae into two metabolic subpopulations. Carbon source optimization allows directional regulation of metabolic subpopulation dynamics, thereby improving the production of target products.
  Savigny J, *et al., Nat Commun*, 2026, 17(1):645

- Through combined mutagenesis and high-throughput flow Raman sorting, a mutant strain of Saccharomyces cerevisiae with a lipid content of up to 40.26% was successfully obtained, and its lipid accumulation mechanism was revealed.
  Ji X, *et al., Biotechnol Biofuels Bioprod*, 2025, 18:75

- The power of a novel Raman flow cytometry sorting technology was demonstrated through the identification of high-DHA-producing strains by rapid screening of a Schizochytrium mutant library.
  Wang X, *et al., Proc Natl Acad Sci U S A*, 2025, 122(22): e2503641122.

- A Raman flow cytometry-based rapid probiotics detection technology enabled accurate and rapid classification, enumeration, and viability assessment of strains in probiotic products.
  Zhang J, *et al., iMetaOmics*, 2025: e70024.

- Single-cell Raman spectroscopy enabled simultaneous assessment of viability and cryotolerance in industrial yeast strains.
  Sun X, *et al., Synth Syst Biotechnol*, 2024, 10(1): 110-118.

- The high-throughput and highly stable Raman flow cytometry technology, pDEP-DLD-RFC, was introduced for metabolic monitoring of plant and yeast biomanufacturing processes, as well as for rapid discrimination of tumor cells and bacterial drug sensitivity testing.
  Wang X, *et al., Adv Sci*, 2023, 10(16): e2207497.

- The Intra-Ramanome Correlation Analysis (IRCA) algorithm was developed to construct a metabolite conversion network from a specific instance of one isogenic cell sample.
  He Y, *et al., mBio*, 2021, 12(4): e01470-21.

- FlowRACS, one of the first flow-based Raman-activated cell sorter (RACS), was introduced to support high-throughput discovery and screening of enzymes and cell factories, without requiring fluorescent labeling of cells or proteins.
  Wang X, *et al., Sci Adv*, 2020, 6(32): eabb3521.

- Using D_2O-labeled single-cell Raman spectroscopy to assess the active phenotypes of soil microorganisms, thereby investigating the impact of microplastic-derived dissolved organic matter (MP-DOM) on soil carbon cycling.
  Wang J, *et al., Environ Sci Technol*, 2025, 59:17334-17348

- Using D_2O-labeled single-cell Raman spectroscopy to identify single bacterial cells with in situ short-cut denitrification function in constructed wetland environments.
  Xie Y, *et al., Bioresour Technol*, 2026, 444:133899

Applications & References

References

- A rapid antimicrobial susceptibility testing (AST) technology for fast-growing mycobacteria was developed, reducing the detection time from 3–5 days (the conventional gold standard) to only 24 hours.
  Ren W, *et al., Ann Clin Microbiol Antimicrob*, 2023, 22(1):94.

- The automated version of CAST-R was developed, reducing the antimicrobial susceptibility testing time for common bloodstream pathogens to 3 hours—achieving a 10-fold acceleration.
  Zhu P, *et al., mLife*. 2022, 1(3):329-340.

- Heavy water (D_2O)-probed Raman microspectroscopy was demonstrated to be effective in assessing the sensitivity of *Acinetobacter baumannii* to tigecycline.
  Hua X, *et al., Emerg Microbes Infect*, 2021, 10(1): 1404-1417.

- The MIC-MA concept and the CAST-R instrument were introduced as a universally applicable approach for rapid antimicrobial susceptibility testing and quantitative assessment of drug efficacy based on metabolic activity inhibition at single-cell resolution.
  Tao Y, *et al., Anal Chem*, 2017, 89(7): 4108-4115.

- Raman Barcode of Cellular response to Stress (RBCS) was proposed to profile and distinguish drug response mechanisms via Ramanome, aiding in antibiotic evaluation, screening of drug-resistant bacteria, and studies of cell-drug interactions.
  Teng L, *et al., Sci Rep*, 2016, 6: 34359.

- Heavy water (D_2O)-probed Raman microspectroscopy was used to identify and sort active microbial cells in mouse cecum samples in the presence of various carbohydrates.
  Berry D, *et al., PNAS*, 2015, 112(2): e194-203.



Functional Single Cells at Your Fingertips.

LinkedIn | eCyte

techsupport@ecytebio.com | www.ecytebio.com
eCyte, Inc. 880 W Maude Ave, Sunnyvale, CA 94085-2920

FOR RESEARCH USE ONLY. NOT FOR USE IN DIAGNOSTIC PROCEDURES.

V2026.1.0