Orbitrap Astral MS

Enhancing immunopeptide profiling with Orbitrap Astral mass spectrometer for unbiased discovery of neoantigens

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Abstract

Purpose: Demonstrate the performance of Thermo Scientific™ Orbitrap™ Astral™ mass spectrometer and Thermo Scientific™ Vanquish™ Neo UHPLC system in the analysis of major histocompatibility complex (MHC) peptides.

Methods: A label-free DDA-based method is demonstrated with low input MHC peptides from HCT 116 cells.

Results: Our results show that Orbitrap Astral MS coupled to Vanquish Neo UHPLC system has sensitivity to enable immunopeptidomics studies.

Introduction

Immunopeptidomics is the study of the peptides presented by MHC molecules on the surface of cells. These MHC peptides have major implications for many areas of research, including immunotherapy and personalized medicine. For example, many studies in this field aim to identify low-level tumor specific antigens (TSAs) with the goal of developing personalized immunotherapies to target cancerous cells with a high degree of specificity. Mass spectrometry (MS) allows for direct immunopeptidomics analysis, enabling simultaneous identification and quantification of thousands of MHC peptides in a single run. The recently developed Orbitrap Astral mass spectrometer has enabled new levels of sensitivity and selectivity to provide deeper insights into the immunopeptidome. In this study, we utilized the Orbitrap Astral mass spectrometer to characterize the immunopeptidome extracted from HCT 116 cells to support the detection and annotation of potential neoantigens.

Materials and methods

Sample Preparation

Class I MHC peptides were obtained by immunocapture with a pan-specific MHC class I antibody, W6/32-conjugated resin on 100 million HCT-116 cells. After cleanup on StageTips, the starting material was diluted 100x with 0.1% formic acid. Samples were diluted to represent the equivalent of E+4 to E+6 cells of extracted IMP.

LC-MS/MS method

Peptides were separated on a Vanquish Neo UHPLC system in trap and elute configuration. Thermo Scientific™ PepMap™ Neo Trap Cartridge and IonOpticks Aurora Ultimate™ column (25 cm x 75µm) were used. Total run time was 72 min. Thermo Scientific™ EASY-Spray™ Ion Source was used coupled to the Thermo Scientific™ FAIMS Pro Duo interface. Peptides were analyzed by the Orbitrap Astral mass spectrometer.

Data Processing

The data analysis was performed using PEAKS Studio software (ver. 11) with the DeepNovo Peptidome workflow for database search and de novo peptides identification. Spectra were searched against the UniProt human database (20,607 sequences) with the no-enzyme option.

Search Engine Name: PEAKS
Parent Mass Error Tolerance: 10.0 ppm
Fragment Mass Error Tolerance: 0.02 Da
Enzyme: None
Peptide Length Range: 6 - 45
Database: Human_UniProt
Taxon: all species
Searched Entries: 20607
Deep Novo Score: 70.00%
Deep Novo Protein Association Tag Sharing: 5
Confident Amino Acid Threshold: 2.00%

Figure 1. PEAKS DeepNovo workflow settings.

Figure 2. Experimental workflow from sample preparation to data analysis.

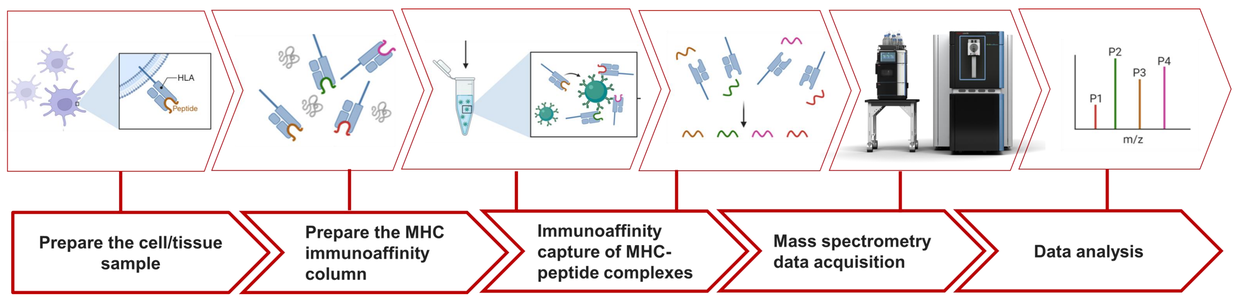


Figure 3. Experimental set-up for immunopeptidomics analysis. This workflow combines the high sensitivity and throughput offered by the Vanquish Neo UHPLC system with low flow with the speed of Orbitrap Astral coupled to FAIMS Pro duo interface for higher sensitivity.

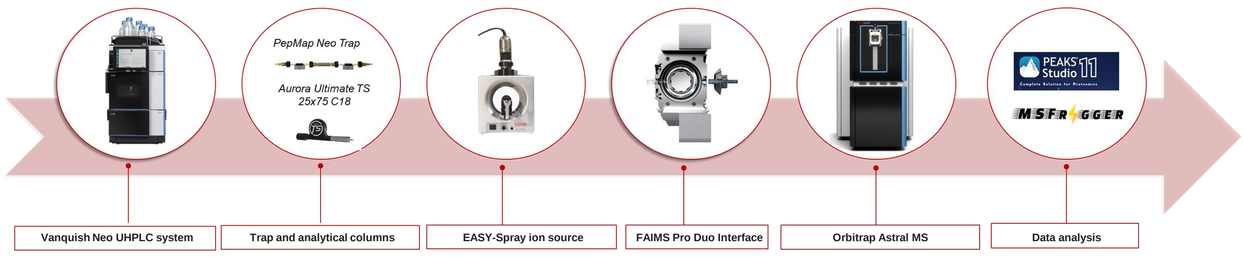


Table 1. LC-MS settings. Trap and Elute configuration was used.

Time (min)	Duration (min)	%B	Flow rate (µL/min)
Run			
0.0	0.0	2.0	0.5
1.0	1.0	5.0	0.5
1.1	0.1	5.0	0.2
61.1	60	35.0	0.2
Column wash			
63.1	2.0	70.0	0.2
67.1	4.0	99.0	0.2
67.2	0.1	99.0	0.5
72.0	4.8	99.0	0.5

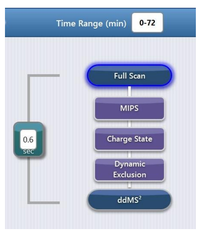


Figure 4. Components of each experiment

Table 2. MS settings

	Property	Setting
Source	Spray Voltage	1.9 KV
	Capillary Temp	275
	FAIMS CV	- 50 V and -70 V
	Total carrier gas flow (L/min)	3.5
Full MS	Scan Range (m/z)	300-1500
	Orbitrap Resolution	120000
	Max IT (ms)	100
	RF Lens (%)	45
	AGC Target (%)	300
DDA	Data dependent Mode	Cycle Time
	Time between Master scans	0.6 s
	Isolation window	2 m/z (for ultra low loads) or 1m/z (≥E+6)
	Detector Type	Astral
	HCD Collision Energies	29
	Scan Range	110-2000
	AGC Target (%)	30
	Max Injection Time (ms)	100

Results

Figure 5. Base peak chromatograms of HCT116 sample injected at different loads using the method described above.

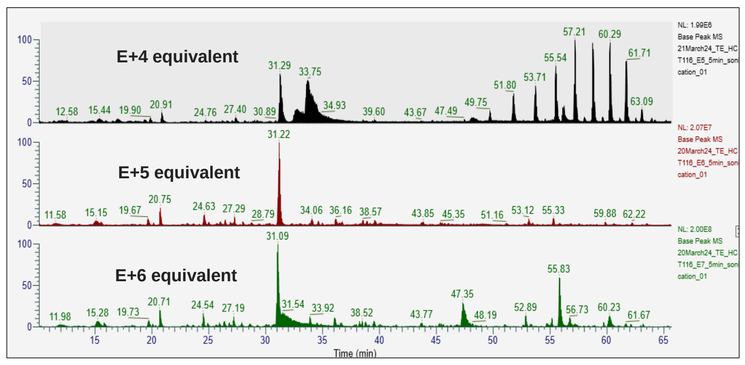
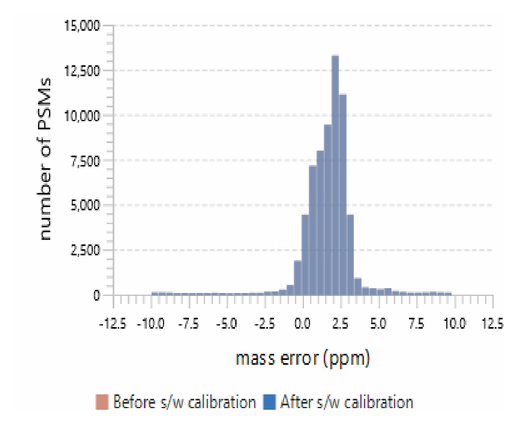
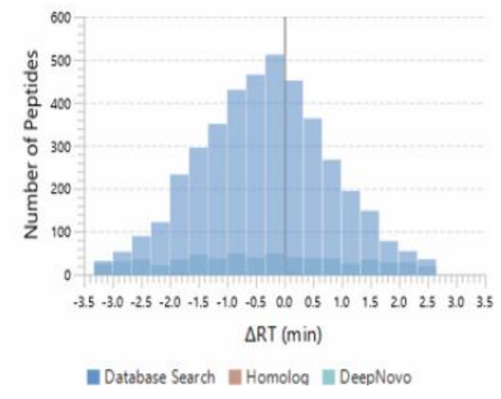


Figure 6. PEAKS DeepNovo results of E+5 cell equivalent load. A) Distribution of precursor mass error of filtered PSM in ppm. B) Histogram of peptide ΔRT

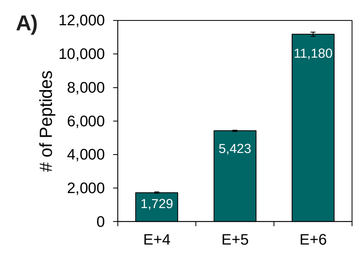


A) *Great mass accuracy at ultra low loads*

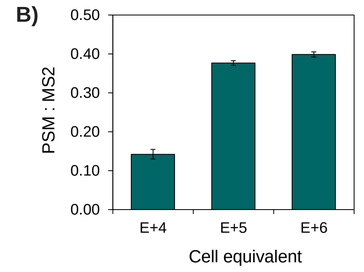


B) *Majority of peptides matches to database and only few peptides are DeepNovo or Homolog hits*

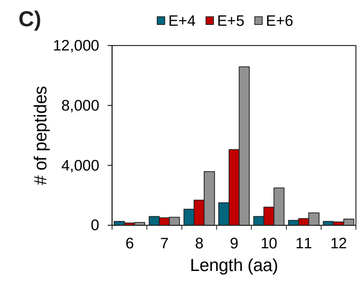
Figure 7. MHC peptides from HCT-116 cells identified using the workflow described.



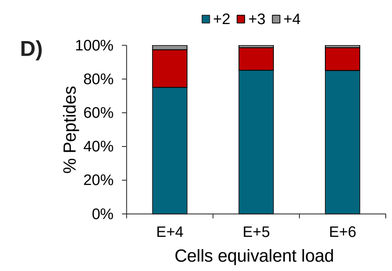
Great sensitivity at low loads.



Success matching rate – PSM:MS2 - is around 40% for low loads



Length distribution of peptides identified in different loads



High proportion of +2 peptides detected in all loads.

Conclusions

- Improved sensitivity of and dynamic range of detection for immunopeptide analysis with the Vanquish Neo UHPLC system coupled to an Orbitrap Astral mass spectrometer equipped with FAIMS Pro Duo interface selectivity enables deeper depth of coverage with higher throughput of analysis
- Improved sensitivity allows for equivalent IMP coverage with >E+4 cell equivalent dilution
- Increased sensitivity allows for compatibility with low levels of material equivalent to samples extracted from tissue biopsy samples

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