

# ANALYSIS OF PEGs BY ESI-IMS-TOF MS COUPLED WITH ION-MOLECULE REACTIONS

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## OVERVIEW

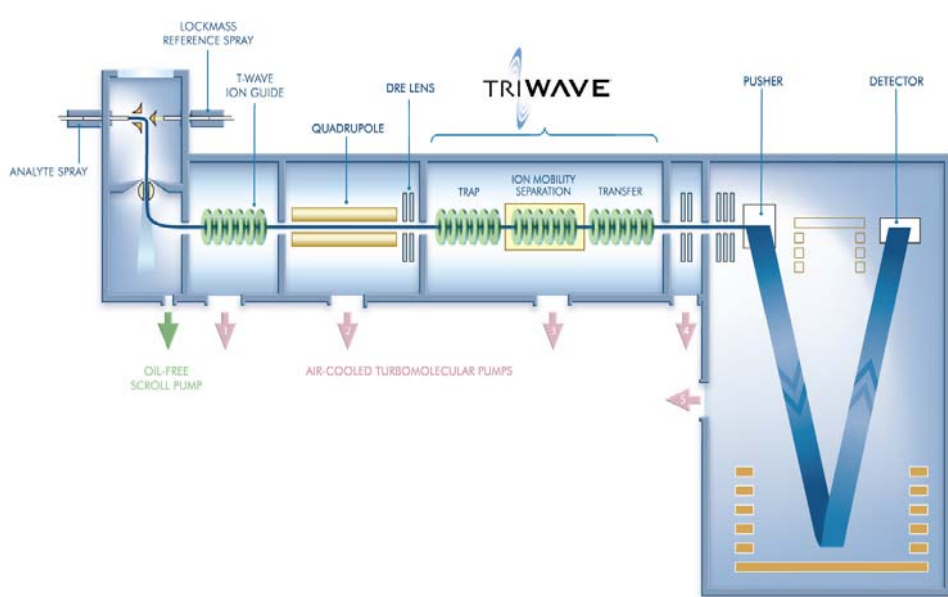
- Poly (ethylene glycols) (PEGs) and its derivatives are widely used in the biopharmaceutical industry for the delivery of therapeutic drugs.
- Mass spectrometric analysis of high molecular weight PEGs is very challenging due to the great complexity and diversity of the materials.
- The use of gas phase ion-molecule reactions for the analysis of PEG and PEGylated proteins has precedent within the biopharmaceutical industry today<sup>1</sup>.
- This presentation describes an improved method to accurately measure the average molecular weight of PEGs using ion-mobility time-of-flight mass spectrometry coupled with gas-phase ion-molecule reactions.
- The method is developed based on a simple and flexible modification to SYNAPT™ HDMS™ System with off-the-shelf components, thus enabling a gas-phase ion-molecule reaction to be effectively coupled to the high-performance tandem mass spectrometer without sacrificing any high performance attributes of the original instrumentation<sup>2</sup>.



**Sample preparation.** Samples were prepared at analyte concentrations of 1–2 mg/mL either in a 50/50 (v/v) solution of water and methanol or 10 mM ammonium acetate and methanol. The solutions were directly infused into the ESI source at 10 µL/min by a syringe pump.

MS Conditions  
MS System: Waters SYNAPT™ HDMS™  
Ionization Mode: ESI Positive  
Capillary Voltage: 3.0kV  
Cone Voltage: 40V  
Source Temp: 100°C  
Desolvation temp: 250°C  
IMS Cell Pressure: 0.5 mbar (n2)  
Wave Pulse Height: 5-14 V  
RF Amplitude: 320 V (Peak-to-Peak)  
IMS Cell Velocity: 240 m/s

## ADDING ION MOBILITY TO A Q-TOF MS



- The ion-mobility section is comprised by three Traveling Wave-enabled Stacked Ring Ion Guides (SRIG).
- The TRAP ion guide is used to accumulate ions and release them as packets for ion mobility separation.
- The TRANSFER ion guide conveys the mobility separated ions to the oa-TOF for mass analysis.
- Gas phase ion-molecule reactions can take place either in the TRAP cell or in the TRANSFER cell.

## SYSTEM CONFIGURATION FOR ION/MOLECULE REACTIONS

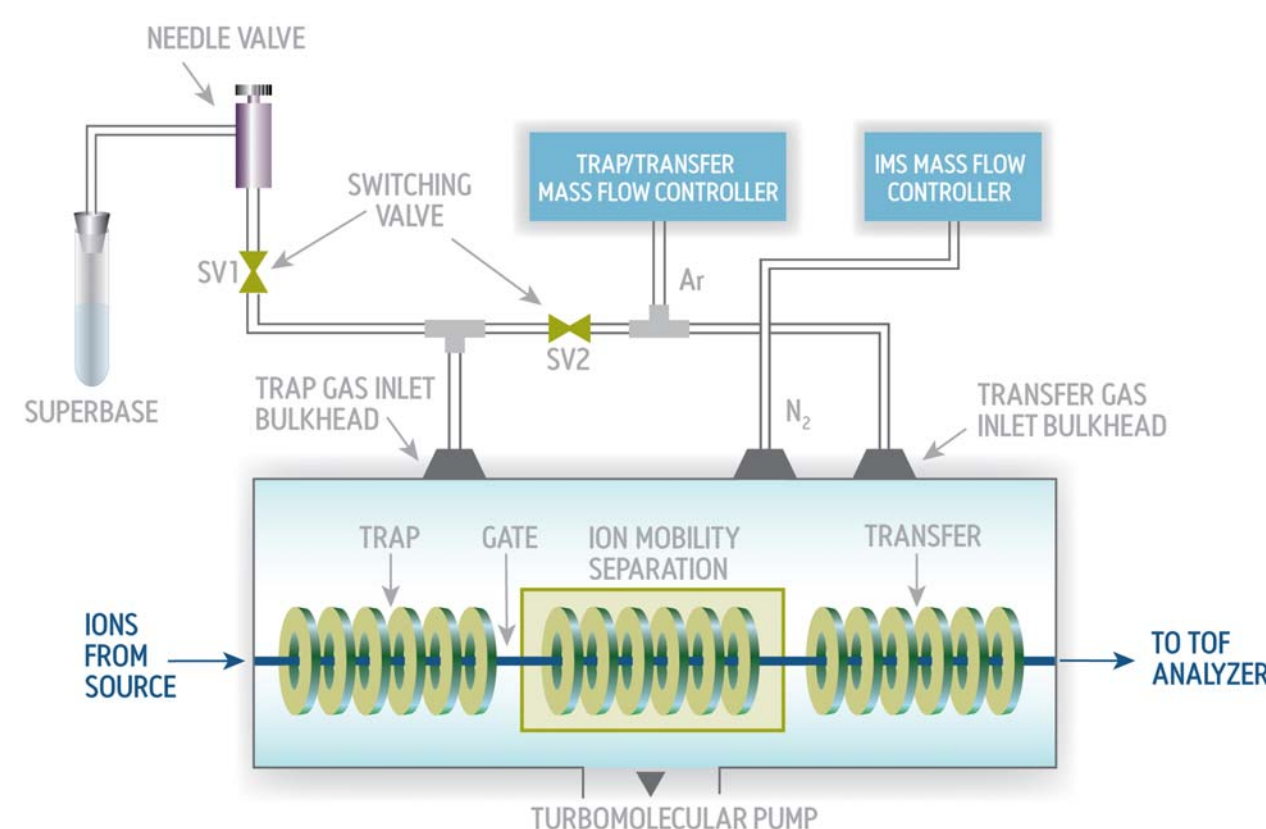


Figure 1. Instrument (SYNAPT HDMS) schematic illustrating the TriWave™ Technology embedded in a high-performance oa-TOF tandem mass spectrometer (A). Schematic diagram showing the modified gas line configuration for performing ion/molecule reaction inside the TRAP cell of SYNAPT HDMS Mass Spectrometer (B).

## ESI-TOF ANALYSIS OF PEG 4450

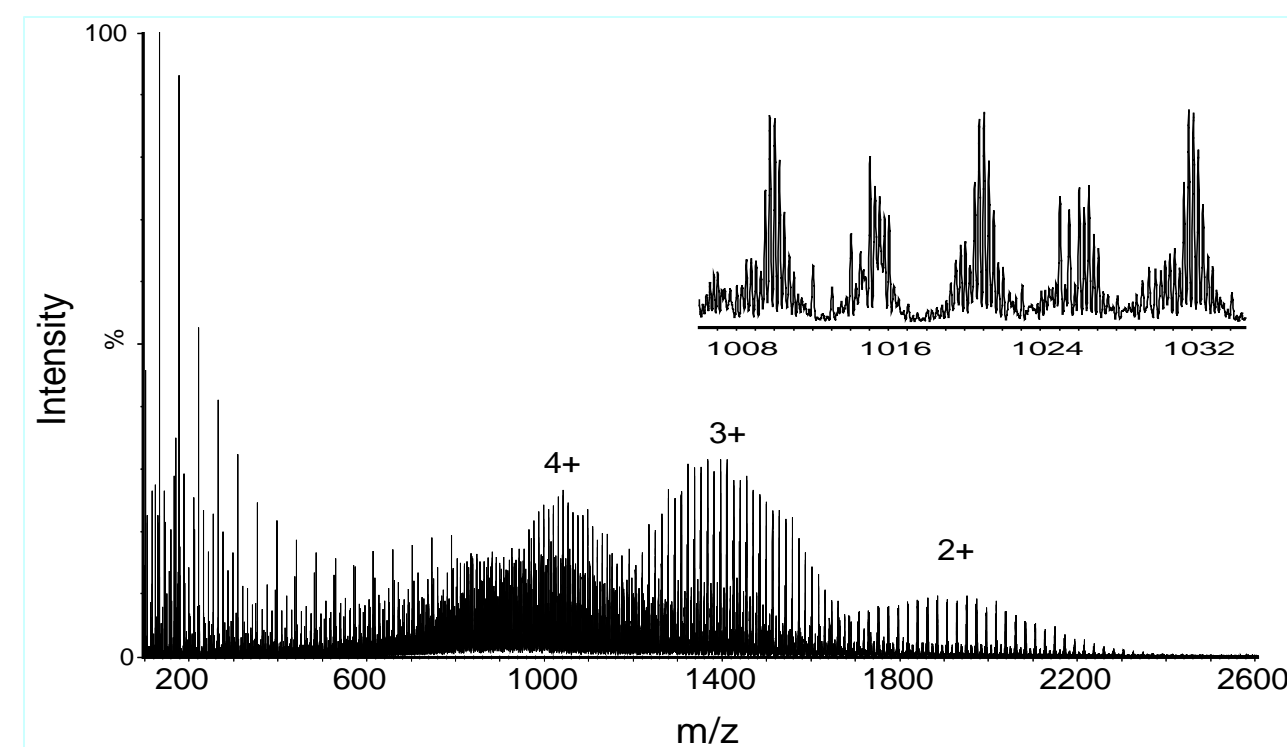


Figure 2. ESI-TOF mass spectrum of PEG 4450 without IMS separation. The isotopic resolution for peaks in the spectrum (inset) demonstrating the sufficient resolving power of the instrument at the collected m/z window. The isotopic resolution permits the determination of the number of charges that each oligomer holds and their charge states distribution in the spectrum. As depicted in the Figure above, spectrum contain several charge states ranging from 2+ to 4+ that are due to the attachment of multiple cations (e.g., Na+, K+, and H+) to each PEG oligomer, generating many different ion series in the spectrum. Consequently, the average molecular weight cannot be readily determined.

## ESI-IMS-TOF ANALYSIS OF PEG 4450

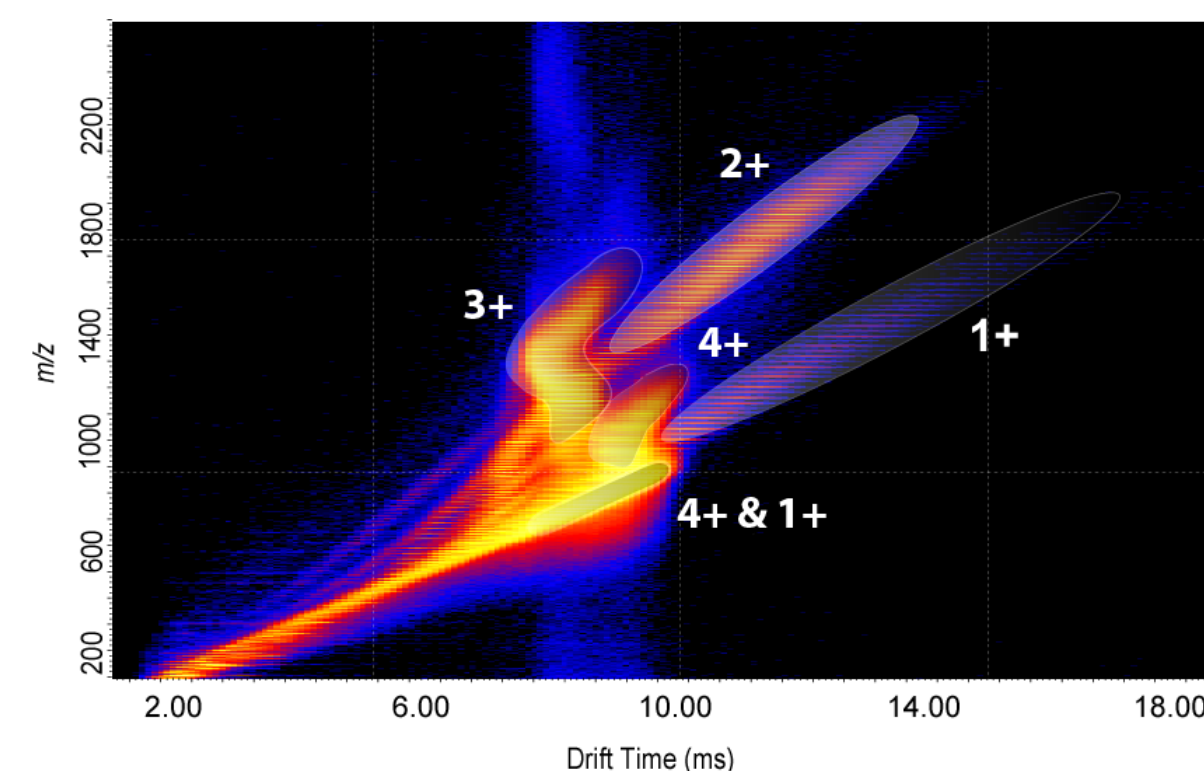


Figure 3. ESI IMS TOF analysis of PEG 4450 using SYNAPT HDMS. Driftscope shows the gas-phase separation power of Synapt in the analysis of PEG 4450. Components with different charge states (1+ to 4+) are separated via ion-mobility, thus enabling the examinations of different (minor) components in the PEG materials.

## Charge Stripping Analysis of PEG 4450

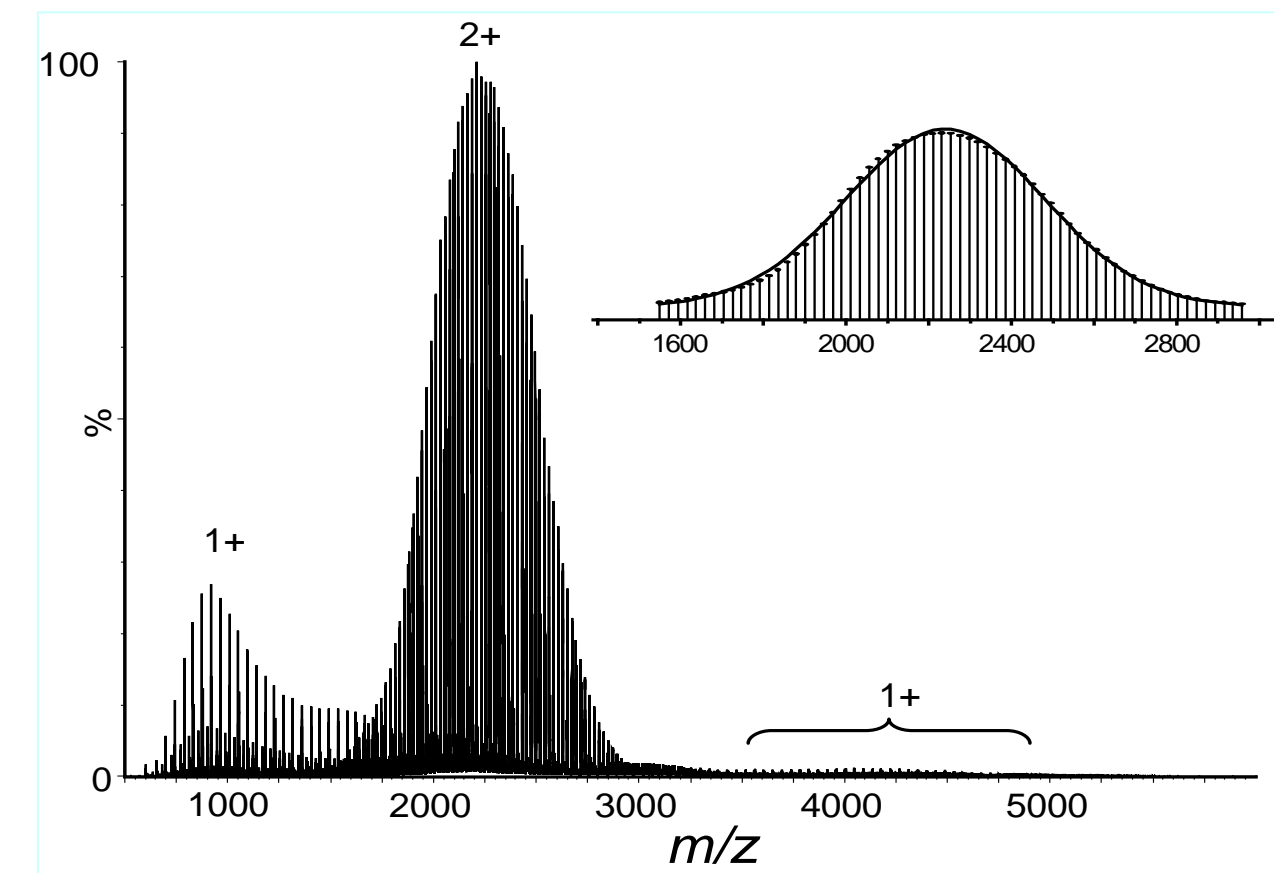


Figure 4. ESI-TOF mass spectrum of PEG 4450 after reaction of all charge states in the trap cell of the instrument with super base, 1,8-diazabicyclo[5.4.0]-undec-7-ene (DBU). The inset shows the expanded view of the best fit to a Gaussian distribution.

## Charge stripping Analysis of PEG 20kDa

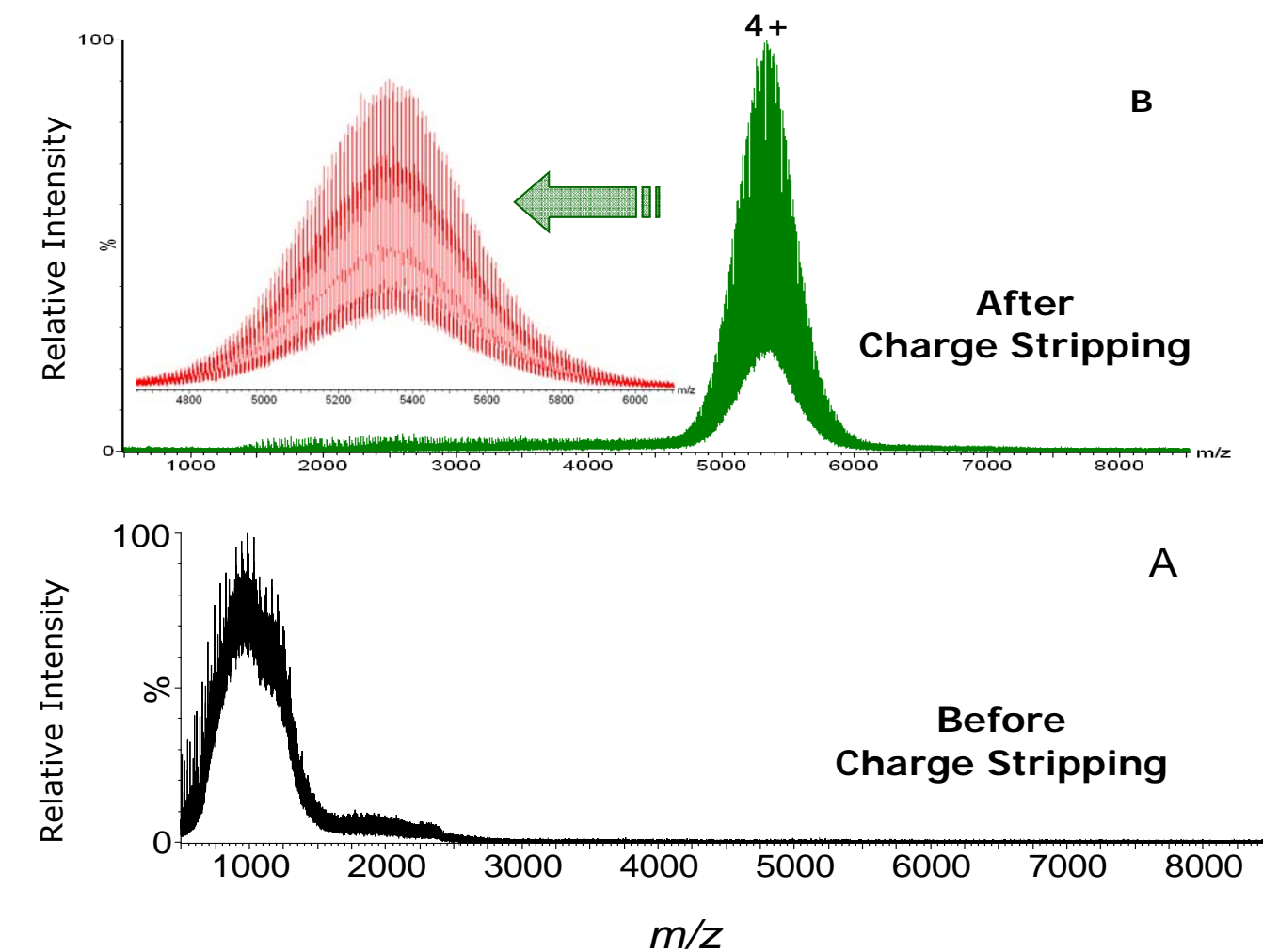


Figure 5. ESI-TOF mass spectrum of PEG-aldehyde 20 kDa before (A) and after (B) reaction with super base, DBU, in the TRAP cell of the Triwave. Reaction conditions were optimized to strip all the charge states of PEG-aldehyde 20kD down to only 4+ charge state.

## Charge stripping Analysis of PEG 20kDa

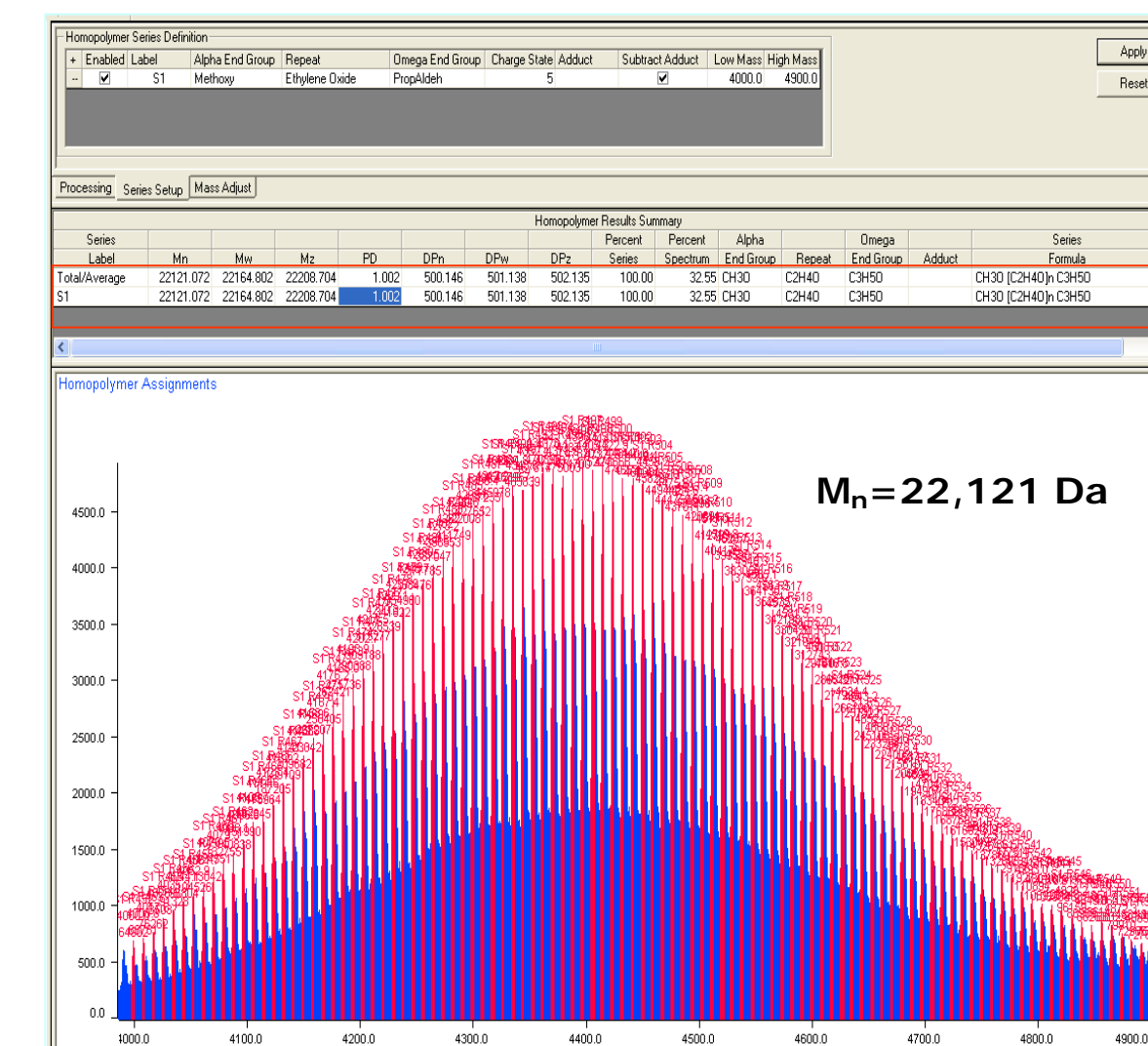


Figure 6. Processed ESI-TOF mass spectrum of PEG-aldehyde 20 kDa after reaction with DBU in the TRAP cell of the Triwave. Mass spectrum was processed using Polymerix™ software (Sierra Analytics) to obtain number average molecular weight ( $M_n$ ), weight average molecular weight ( $M_w$ ), third order molecular weight moment ( $M_z$ ), polydispersity (PD), degree of polymerization ( $DP_w$ ), and average repeat count ( $DP_z$ ). The average MW value (22,121 Da) is in close agreement with the literature value measured by similar MS approach as well as an NMR method (21,920 Da).

## CONCLUSIONS

- We have demonstrated a method to accurately measure the average MWs and MW distributions of large PEG using ion-molecule reaction inside a Waters SYNAPT HDMS Mass Spectrometer.
- With many unique capabilities of the instrument, such as ion-mobility separation, the ability to perform ion-molecule reaction inside SYNAPT HDMS has truly expanded the applicability of the instrument. It is conceivable that this configuration can be readily applied to many challenging analytical tasks in pharmaceutical industry.

References:  
1. Bagal et.al Anal. Chem. **80**, 2408–2418 (2008).  
2. Chakraborty et.al Pharmaceutical Technology JULY 2008