Frequently Asked Questions About the Varian 500-MS Ion Trap Mass Spectrometer

1. **What is the difference between an ion trap mass spectrometer and a triple quadrupole mass filter?**
    a. Ion traps LC/MS instruments receive ions from the API interface, trap and store the ions, with a broad range of masses, simultaneously within the trapping electrodes and eject the ions into an ion detector in sequential mass order during mass scanning. MS/MS and MS^n can be done by mass isolating one of the masses initially injected into the trap, effecting collision induced dissociation (CID) and mass scanning to produce the spectra. These events all occur with in the same trapping electrodes. Triple quadrupole mass filters receive ions from the API interface and sequentially filter ions of different masses allowing one mass at a time to be passed on to an ion detector. MS/MS can be effected by using a mass filter to select a precursor mass followed by a separate collision cell where CID occurs, followed by a second mass filter to select the product ion that is passed on to the detector. The MS/MS steps occur simultaneously and are distributed in space among the three electrode structures.
2. **What are the strengths of an ion trap mass spectrometer?**
    a. Fast, sensitive full scan spectra for MS and MS/MS. Excellent high mass sensitivity. The ability to elucidate structure by using MS^n and low price.
3. **What are the weaknesses of an ion trap mass spectrometer?**
    a. The ability to handle a very heavy matrix that co-elutes with the sample.
4. **What are the strengths of a triple quadrupole mass filter?**
    a. Good quantitation in a very heavy matrix. Can use many precursor/product ion MRM transitions with different precursor masses for confirmation and quantitation. The mass resolution can be adjusted to trade off mass resolution for ion transmission and sensitivity.
5. **What are the weaknesses of a triple quadrupole mass filter?**
    a. Slow scan speed, low duty cycle and low sensitivity in full scan, poor high mass sensitivity. More components, electronics and therefore more expensive.
6. **What applications are best done by an ion trap mass spectrometer?**
    a. Applications where sensitive, fast scanning of the full spectra are required, such as screening of unknown samples, fast liquid chromatography separations producing narrow sample peaks, and MS/MS where the full product spectra is required on narrow sample peaks.
7. **What applications are best done by a triple quadrupole mass filter?**

a. Applications where SIM or MRM can be used for trace detection and quantitation in very a heavy matrix like urine or plasma that has little or no sample preparation.

8. **Why is the mass resolution of the Varian 500-MS ion trap LC/MS better than other ion trap competitors**?

    a. The patented triple resonance mass scan.

9. **Why are electrospray spectra so noisy on most instruments?**

    a. Noise can come from large charged droplets that enter the mass analyzer and eventually strike the ion detector causing very large random noise spikes. Large, high kinetic energy, multiply charged solvent clusters also can pass through the ion gate and enter the mass analyzer during the mass scan and strike the ion detector.

10. **Why is the signal-to-noise of the Varian 500-MS ion trap LC/MS better than other ion trap competitors?**

    a. The patented tilted API capillary and ion guide axis design prevents large droplets from entering the mass analyzer and generating noise. The patented gating optics also eliminates high energy multiply charged solvent clusters from entering the mass analyzer during the mass scan, there by reducing the chemical noise.

11. **What is unique about the Varian API (atmospheric pressure ionization) interface?**

    a. The drying gas can be temperature programmed for optimum temperature during a gradient run.

12. **Can ion traps be used for quantitation?**

    a. Yes! Varian has a long history with GC ion trap mass spectrometers used for routine high sample through put quantitation. Varian had the first commercial turn-key MS/MS system on an ion trap. The Applications section of the Varian Web site lists a bibliography of customer applications, publications, and Varian Application Notes showing the GC ion trap used for quantitative applications.

13. **How are negative ions detected in the 500-MS?**

    a. Ions are detected by impacting them on a high voltage (15 kV) metal dynode (a conversion dynode) that ejects charges of opposite polarity to the initial ion. The ejected ions are focused into an electron multiplier for measurement by an electrometer. Positive ions are attracted to the negatively biased conversion dynode and electrons are ejected and focused into the cone of the electron multiplier. Negative ions are attracted to positively biased conversion dynode and are converted to positive ions, which are ejected and focused into the cone of the electron multiplier.

14. **Why is temperature programming of the drying gas important?**

    a. Typical LC gradient separations start with a high aqueous content and increase the organic composition of the mobile phase during the gradient. Therefore, for a

fixed liquid flow, the heat required to optimally evaporate the solvent will decrease during the gradient. By decreasing the temperature of the drying gas during the gradient as the organic composition increases, maintains the optimum heat transfer to the droplets for evaporation without over heating the sample and causing thermally labile compounds to be lost.

15. **Why is an ion trap LC/MS lower in price than a triple quadrupole?**
    a. The triple quadrupole requires separate mass filters to select the precursor and product masses for MS/MS; as well as a separate collision cell. MS/MS is done simultaneously in time and sequentially in space. These three elements require their own power supplies for the RF and DC voltages required for mass filtering. An ion trap performs precursor mass selection, CID and product ion scanning sequentially in time, but within the same trap electrodes, thereby reducing the amount and cost of the hardware.

16. **Why is the sensitivity for large mass-to-charge ratio ions better in an ion trap than a triple quadrupole?**
    a. Transmission quadrupole mass filters generally scan such that the width of a mass peak is constant. This requires that the mass resolution increase as the larger masses are scanned. This reduces the ion transmission through the mass filter as the mass increases. This affect becomes significant above mass 400.

17. **How does the sample matrix affect the detection limits in an ion trap?**
    a. The ion trap has a finite charge capacity. In the extreme, ions from the matrix, if in great excess of the sample ions, will fill the trap to its capacity and only a few sample ions will be trapped.

18. **Why can the Varian ion trap scan so fast and still have good mass resolution?**
    a. The patented Varian triple resonance mass scan causes the ion amplitudes to be increased exponentially with time and thus the ions are ejected from the trap very quickly. Conventional resonant ion ejection causes the ion amplitudes to be increased linearly with time and therefore the ions are ejected more slowly.

19. **Why is fast mass scanning useful?**
    a. More full scan spectra can be obtained across a narrow chromatographic peak.

20. **When is full scan product ion scanning more useful than MRM (multiple reaction monitoring)?**
    a. When data dependent scanning is used, the precursor ion is not known a priori and therefore the product ions produced from collision induced dissociation is not known. Therefore a fast scan of the entire mass range will usually identify all of the product ions produced.

21. **When is MRM more useful?**
    a. If only one product ion mass is monitored in a triple quadrupole mass filter the duty cycle is almost 100% and the best sensitivity is obtained. If the number of

product ion masses monitored increases the ion trap will have the duty cycle advantage.

22. Why is electrospray droplet evaporation with a heated countercurrent drying gas better than desolvating the droplets in a heated capillary API?

a. Heating the charged droplets from the electrospray to evaporate the solvent allows the uncharged matrix and solvent to be forced away from the capillary API inlet and prevents it from entering the vacuum chamber and contaminating the skimmer and ion guide. Evaporating the droplets inside of a heated API capillary deposits contamination inside of the capillary. The solvent will also cause charge transfer from highly charged samples, like proteins, to the solvent; with an increase in the mass-to-charge ration of the ions. Often this will move the ions outside of the mass range of the instrument.

23. How was the charge capacity of the trap increased?

a. The charge capacity of the trap was increased by increasing the octapole content of the trapping field.

24. Why is a high charge capacity useful?

a. Increasing the charge capacity allows larger amounts of matrix ions to be trapped without affecting the sensitivity of the system.