

**TABLE OF CONTENT**

<b>CONTENT</b>	<b>PAGE</b>
Acknowledgement	ii
Abstract	iii
Table of Content	iv
List of Table	viii
List of Figure	ix
List of Abbreviation	xi
List of Appendices	xiii
<b>Chapter I    Introduction</b>	
1.1            Introduction to Hard Disk Drive (HDD)	2
1.2            Micro Contamination & Chemical Analysis	4
1.2.1    Ionic Contaminants	5
1.2.2    Particulate Contaminants	5
1.2.3    Organic Contaminants	6

**Chapter II Outgassing of Adhesives & Dynamic Headspace Analysis**

2.1	Outgassing of Adhesives	10
2.2	Headspace Analysis	14
2.2.1	Static Headspace vs. Dynamic Headspace	14
2.2.2	Dynamic Headspace/ GCMS analysis	17
2.2.2.1	Sampling	17
2.2.2.2	Thermal Desorption System (TDS)	20
2.2.2.3	Gas Chromatography-Mass Spectrometer	23
2.3	Objective of Project	26

**Chapter III Experiment**

3.1	Instrument Settings	
3.1.1	Thermal Desorption System (TDS 2)	27
3.1.2	Cold Injection System (CIS 4)	30
3.1.3	GC-MS	32
3.2	Apparatus	34
3.3	Standards & Materials	35
3.4	Standard Solution Preparation Procedure	
3.4.1	Preparation of Semi Quantitative Standard	36
3.4.2	Preparation of Quantitative Standard	36
3.4.3	Preparation of Surrogate Spike Standard	36
3.4.4	Preparation of Adsorbent	36

3.5	Test Procedure	
	3.5.1 Conditioning Adsorbent Tubes	38
	3.5.2 Container Cleanliness Check	38
	3.5.3 Sampling Procedure	38
3.6	Data Analysis Method	
	3.6.1 Semi-quantitative analysis	40
	3.6.2 Quantitative Analysis Method	41
	3.6.2.1 Calibration Plot	41
	3.6.2.2 Check Standard	43
<b>Chapter IV Results &amp; Discussion</b>		
4.1	Semi Quantitative Results	45
	4.1.1 Motor A	46
	4.1.2 Motor B	51
	4.1.3 Motor C	60
	4.1.4 Motor D	61
	4.1.5 Comparison across all motors	62
4.2	Quantitative Results for HEMA, THFA and IBM	65
	4.2.1 Calibration Curve for HEMA	66
	4.2.2 Calibration Curve for THFA	67
	4.2.3 Calibration Curve for IBM	68
	4.2.4 Check Standard	69
	4.2.5 Quantification of HEMA, THFA and IBM	70
4.3	Recovery	71

<b>CHAPTER V: Conclusion &amp; Recommendations</b>	72
<b>References</b>	75
<b>Appendix 1. GC Chromatograms for motor A, B, C, D</b>	80
<b>Appendix 2. Semi Quantitative Results for Chemical Compounds</b>	
<b>Outgassed from motor A, B, C, D</b>	93
<b>Appendix 3. Overlaid GC Chromatograms for HEMA, THFA and IBM</b>	101
<b>Appendix 4. Check Standards Chromatograms</b>	105

**LIST OF TABLE**

	<b>PAGE</b>
Table 1. Comparison of SHS and DHS techniques	16
Table 2. TDS 2 Setting	29
Table 3. Gerstel CIS 4 Setting	31
Table 4. GCMS Method	33
Table 5. HEMA Standard Calibration Range	41
Table 6. THFA Standard Calibration Range	42
Table 7. IBM Standard Calibration Range	42
Table 8. Semi Quantitative Amount (ng) of Acrylates and Methacrylates detected in Spindle Motor A, B, C and D	63
Table 9. HEMA Standard Calibration	66
Table 10. THFA Standard Calibration	67
Table 11. IBM Standard Calibration	68
Table 12. Comparison of the 2 quantification methods	69
Table 13. Quantified Amount (ng) of 2-HEMA, THFA and IBM	70
Table 14. Peak Area of Semi Quantitative Standard deuterated hexadecane-d34	73

**LIST OF FIGURES**

	<b>PAGE</b>
Figure 1. A HDD	3
Figure 2. Siloxane Peak and Its Mass Spectrum	7
Figure 3. Mass Spectrum of Tributylchlorotin	8
Figure 4. Examples of HDD motors	12
Figure 5. Adhesive Application in HDD Motor	13
Figure 6. Gerstel TDS2/CIS4 coupled to Agilent GCMS	21
Figure 7. ATD400 coupled to Agilent GCMS	21
Figure 8. Schematic diagram of a GCMS	23
Figure 9. Basic Mechanism In Mass Spectrometer Detection	24
Figure 10. Gerstel TDS2/ CIS4	27
Figure 11. TDS 2 Oven	28
Figure 12. CIS 4	30
Figure 13. DHS Sampling Container and Oven System	34
Figure 14. Adsorbent tube	37
Figure 15. Mass Spectrum of hexadecane-d34	44
Figure 16. Type of chemical compounds outgassed from Motor A	46
Figure 17. HEMA peak and its standard mass spectrum	47
Figure 18. IBM peaks and the mass spectrum	49
Figure 19. EGDM Peak and Its mass spectrum	50
Figure 20. Types of chemical compounds outgassed from Motor B	51
Figure 21. Tetrahydrofurfuryl Alcohol Peak and Its Mass Spectrum	52
Figure 22. 2-Ethyl hexanol Peak and its mass spectrum	53

Figure 23. Alpha-alpha-dimethylbenzene Methanol Peak and Its Mass Spectrum	54
Figure 24. HEA Peak and Its Mass Spectrum	56
Figure 25. THFA Peak and Its Mass Spectrum	57
Figure 26. HPM Peak and Its Mass Spectrum	59
Figure 27. Types of Chemical compounds outgassed from Motor C	60
Figure 28. Chemical compounds outgassed from motor D	61
Figure 29. Acrylate and Methacrylate detected in Motor A, B, C and D	64
Figure 30. Total Outgas from Motor A, B, C and D	65
Figure 31. Calibration Curve of HEMA	66
Figure 32. Calibration Curve for THFA	67
Figure 33. Calibration Curve for IBM	69
Figure 34. Mass Spectrum for Anthracene-d10	71

**LIST OF ABBREVIATION**

CIS	-	Cold Injection System
DHS	-	Dynamic Headspace
DI	-	Deionized
DOP	-	Diocetyl Phtalate
EGDM	-	Ethylene glycol dimethacrylate
EM	-	Electron Multiplier (EM)
ESCA	-	Electron Spectroscopy for Chemical Analysis
FTIR	-	Fourier Transform Infra Red Spectrometer
GC	-	Gas Chromatography
GCMS	-	Gas Chromatography Mass Spectrometer
HDD	-	Hard Disk Drive
HDI	-	Head Disk Interface
HEA	-	2-hydroxyethyl acrylate
HED	-	High-energy dynode
HEMA	-	2-hydroxyethyl methacrylate
HPM	-	2-hydroxypropyl methacrylate
HSA	-	Headstack Assembly
IBM	-	Isobornyl Methacrylate
IDEMA	-	International Disk Drive Equipment and Material Association
LPC	-	Liquid Particle Counter
MSD	-	Mass Spectrometer Detector
PDMS	-	Polydimethyl siloxane
PSA	-	Pressure Sensitive Adhesives
Rt	-	Retention Time



SEM-EDS	-	Scanning Electron Microscope/Energy Dispersion X-Ray Spectrometer
SHS	-	Static Headspace
TDS	-	Thermal Desorption System
THFA	-	Tetrahydrofurfuryl acrylate
TOF-SIMS	-	Time of Flight-Secondary Ion Mass Spectrometry
UV	-	Ultraviolet

**LIST OF APPENDICES**

- Appendix 1. GC chromatograms for Motor A, B, C and D
- Appendix 2. Semi Quantitative Results for Chemical Compounds outgassed from Motor A, B, C and D
- Appendix 3. Overlaid GC Chromatogram of HEMA, THFA and IBM
- Appendix 4. Check Standard Chromatograms