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Antistatic Sprays

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ABSTRACT

Information on the physical and electrostatic properties of antistatic sprays from several manufacturers is presented. The physical properties examined include the percent nonvolatile residue, percent outgassing, percent moisture absorbency, and corrosiveness. The electrostatic properties examined include static charge accumulation and dissipation measurements.

In addition, the chemical composition of the sprays is determined by infrared spectrophotometry, mass spectrometry, and ultraviolet spectrophotometry.

INTRODUCTION

The control of static electricity is becoming more important with the development and use of very sensitive electronic components. Static electricity can damage electronics, cause excessive instrument noise, and attract unwanted particulates. A number of commercial products are available for controlling static electricity. One such product is antistatic sprays.

Antistatic sprays can be applied (or reapplied) to a surface to neutralize and/or prevent the build-up of static electricity. Some of the uses of antistatic sprays include application on carpet to prevent electric shock, on video screens to reduce particulate accumulation, and on or around electronics to reduce or prevent noise caused by static electricity.

A few years ago it was suggested to use antistatic sprays on nonflight hardware to reduce the noise generated by static electricity. Some concern about using antistatic sprays had been expressed because very little was known about them. Some of the concerns included contamination potential from contact with the spray, corrosiveness, and electrostatic effectiveness of the sprays. This report examines these concerns and presents information on the physical and electrostatic properties, and chemical composition of antistatic sprays. (The manufacturers who participated in this report and their products are listed in Table 1.)

Table 1. List of Manufacturers and Their Products

BOND CHEMICAL PRODUCTS
- *Bond Liquid Static Preventative (BLSP)*
- *Bond #094 (B094)*
- *Bond #142 (B142)*
- *Bond #211 (B211)*
- *Bond #335 (B335)*
- *Bond #506 (B506)*
- *Bond #670 (B670)*
- *Bond #804 (B804)*

THE TEXWIPE COMPANY
- *Texstat (TX140)*

ROGERS ANTISTATIC CHEMICALS
- *RO-20 (RO-20)*
- *AR-AL + AR-8 (AR-AL)*

ACL INCORPORATED
- *General Purpose Staticide (GPS)*
- *Regular Staticide (RS)*

CHEMTRONICS
- *Static Free (SF)*
- *Plast-n-Glas (PNG)*
- *Freez-it (FIT)*

STATIKIL INCORPORATED
- *Statikil (SK)*

PHYSICAL PROPERTIES

The following physical properties were examined: percent nonvolatile residue (NVR), percent outgassing, and percent moisture absorbency.

The percent NVR was calculated by collecting a sample of the antistatic spray solution in a preweighed dish and weighing it. The antistatic sprays examined were either alcohol or water based. The solution was allowed to evaporate for three days in air at room temperature and then weighed again. The residue present in the dish is the NVR. Since the weight of the solution and NVR is known, the percent NVR can be calculated.

In addition to the NVR, the outgassing of the antistatic sprays was examined. The percent outgassing was determined by using the NVR. The weighed NVR was placed in a vacuum oven operating at 100 millitorr at room temperature for 24 hours. After this time, the samples were reweighed and the percent outgassing determined. (The American Society for Testing and Materials method of testing outgassing was not used because it operates at a temperature of 125 °C; these antistatic sprays will not be exposed to this condition.)

Another property examined was the moisture absorbency of the sprays. The percent moisture absorbency was also determined from the NVR. After being removed from the vacuum oven and exposed to room conditions (approximately 22 °C and 65 percent relative humidity) for several days, the weight of the NVR was recorded. The weight change in the NVR was attributed to absorbing moisture from the air.

Finally, the corrosiveness of the antistatic sprays was examined. The sprays were applied to one-half of a mirror surface; the other half was used as a control. The mirror was coated with aluminum. After a six-month period, the mirrors were reexamined for any signs of corrosion.

ELECTROSTATIC PROPERTIES

In addition to the physical properties, electrostatic properties of the antistatic sprays were also examined. The electrostatic properties of interest include static charge accumulation and dissipation measurements. Both measurements can be obtained from a triboelectric testing instrument.

The triboelectric testing instrument is used for testing the triboelectric properties of materials. Its purpose is to simulate the charges applied to a surface when friction occurs. Charges are applied to a sample by a Teflon rubbing wheel, which contacts the sample surface. The triboelectric testing instrument consists of a controller, recorder, electrometer, and triboelectric device. A glove box hooked to a dry nitrogen source controls the relative humidity during the tests. Relative humidities of 20, 40, and 60 percent were used to test the sprays. The sprays were applied to one side of a Mylar film, which was mounted in a sample holder designed for the instrument. The samples were then preconditioned for 24 hours before testing.

CHEMICAL COMPOSITION

Instruments such as the infrared and ultraviolet spectrophotometer, and mass spectrometer provide information on the chemical composition of materials. The chemical composition can be useful for explaining or predicting the effects of the antistatic spray on other materials.

The infrared spectrophotometer (IR) provides information on the molecular bonds present in a compound. A Perkin-Elmer

283B Infrared Spectrophotometer was used to analyze the samples. Wavelengths from 400 to 4000 cm^{-1} were scanned. The samples were prepared by letting the solvent of the antistatic spray evaporate and performing an analysis on the nonvolatile residue. The NVR was placed on a potassium bromide crystal.

The mass spectrometer provides information on the mass fragment characteristic of the compound, and can be used for identification purposes. A Hitachi/Perkin-Elmer RMU-6 Mass Spectrometer was used. The NVR of each antistatic spray was analyzed using pyrolysis mass spectrometry.

The ultraviolet spectrophotometer provides information in the ultraviolet region of the compound. This information is useful for determining the effects of antistatic spray contamination on ultraviolet instruments. A Beckman DK-2A Spectrophotometer was used. The wavelength examined ranged from 205 to 360 nanometers. The antistatic spray solutions were dissolved in a ratio of 1:3 (by volume) in isopropanol, placed into quartz cuvettes, and analyzed.

RESULTS & DISCUSSION

PHYSICAL PROPERTIES

The percent nonvolatile residue, percent outgassing, percent moisture absorbency, and corrosiveness were examined because of the possibility of the antistatic sprays contaminating surrounding surfaces.

Some of the sprays leave a significant amount of NVR on a surface. The NVR can be transferred from one surface to another by contact. The percent nonvolatile residue is presented in Table 2 and in Figure 1. Most of the sprays have a NVR less than 1 percent. SK had the highest NVR - over 8 percent.

Table 2. Physical properties

SAMPLE	*%NVR*	*%OUTGASSING1*	*%MOISTURE*
BLSP	*0.89*	*3.1*	*2.7*
B094	*0.52*	*9.2*	*7.6*
B142	*0.72*	*1.0*	*5.2*
B211	*0.77*	*7.5*	*11.4*
B335	*0.39*	*1.2*	*8.1*

Table 2. Physical properties (continued)

B506	*0.68*	*6.1*	*6.9*
B670	*1.07*	*8.9*	*6.1*
B804	*0.52*	*2.2*	*1.1*
TX140	*1.57*	*15.3*	*45.2*
RO-20	*1.59*	*6.4*	*6.6*
AR-AL	*0.92*	*9.7*	*26.5*
GPS	*0.59*	*1.1*	*4.7*
RS	*1.23*	*2.5*	*5.9*
SF	*0.49*	*-**	*-**
PNG	*0.35*	*-**	*-**
*FIT**	*N/A*	*N/A*	*N/A*
SK	*8.35*	*11.2*	*8.8*

1 - Most of the outgassing is due to moisture.
** - Insignificant change in weight*

The percent outgassing and moisture absorbency are also presented in Table 2 and in Figures 2 and 3, respectively. Measurement of the percent outgassing gives an indication of the contamination that can occur by outgassing. Outgassing products can condense on cool surfaces such as mirrors and affect an instrument's performance. Over half of the sprays outgas over 5 percent of their weight. Most of the outgassing is due to moisture because most of the sprays also show a high percent moisture absorbency. Measurement of the percent moisture absorbency can give an indication of how well an antistatic spray works, since some sprays work by forming a conductive moisture layer to dissipate static charges. Sprays with a high moisture absorbency generally show better charge dissipation properties.

The corrosiveness of the antistatic sprays on an aluminum surface is presented in Table 3. Approximately half of the samples tested corroded or etched the aluminum off the mirror. The two most corrosive sprays are TX 140 and AR-AL. Chemical analysis of these sprays indicate that they contain an amine compound. Amine compounds are slightly basic and can attack metal surfaces such as aluminum. The sprays that are slightly to moderately corrosive (B142, B211, GPS, RS, B506, RO-20, and SK) also contain an amine and/or an

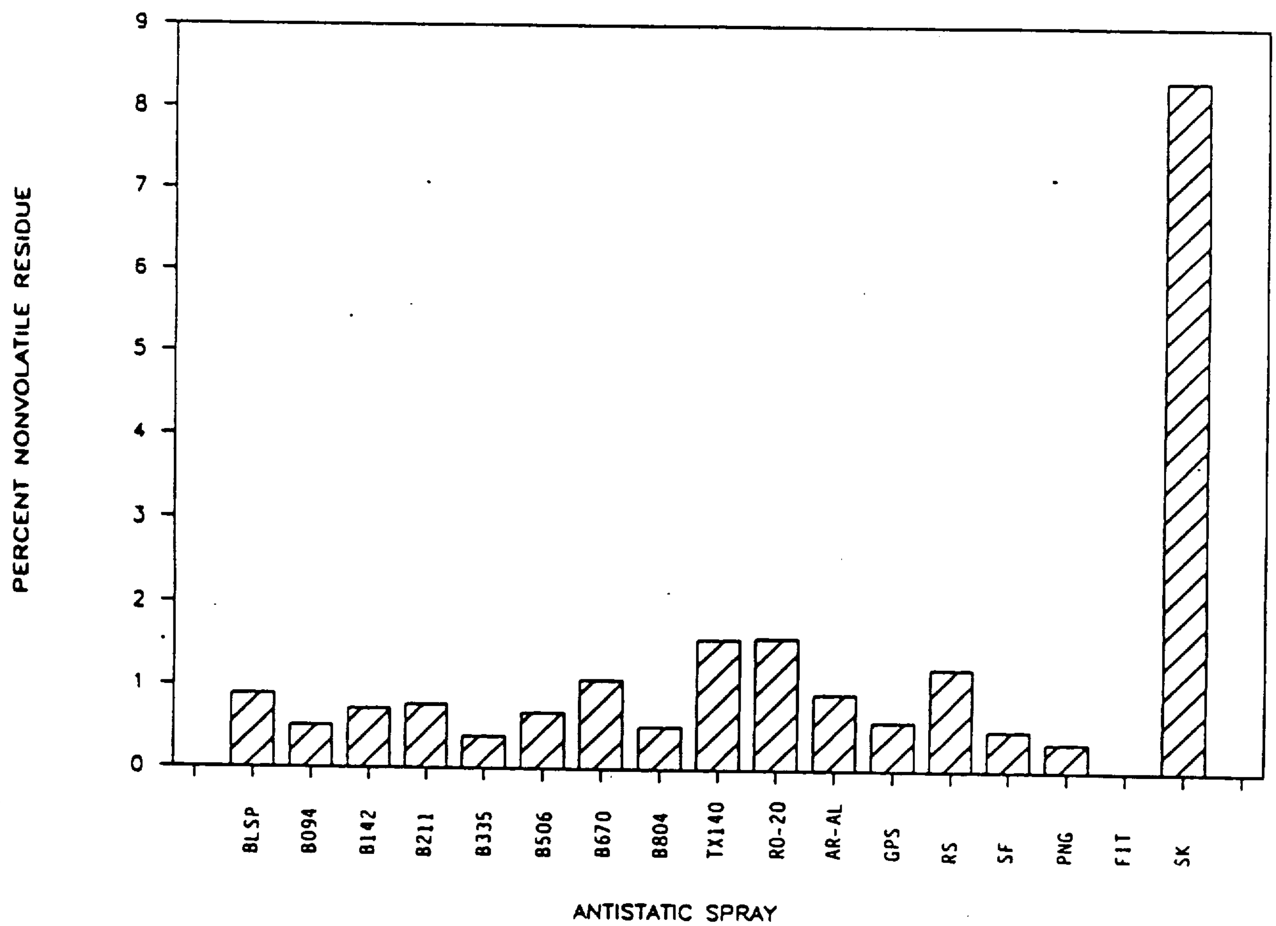

Figure 1. Percent Nonvolatile Residue

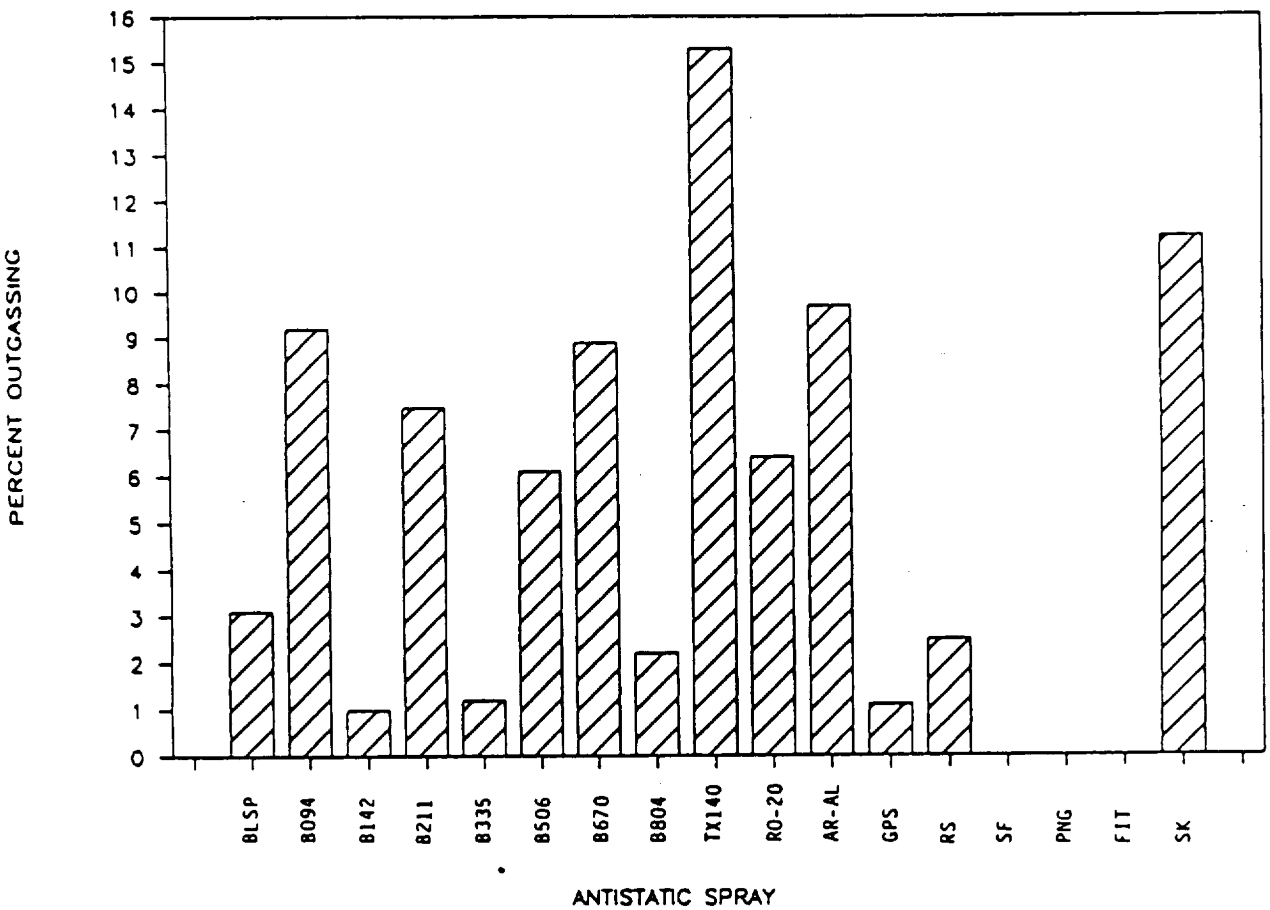

Figure 2. Percent Outgassing

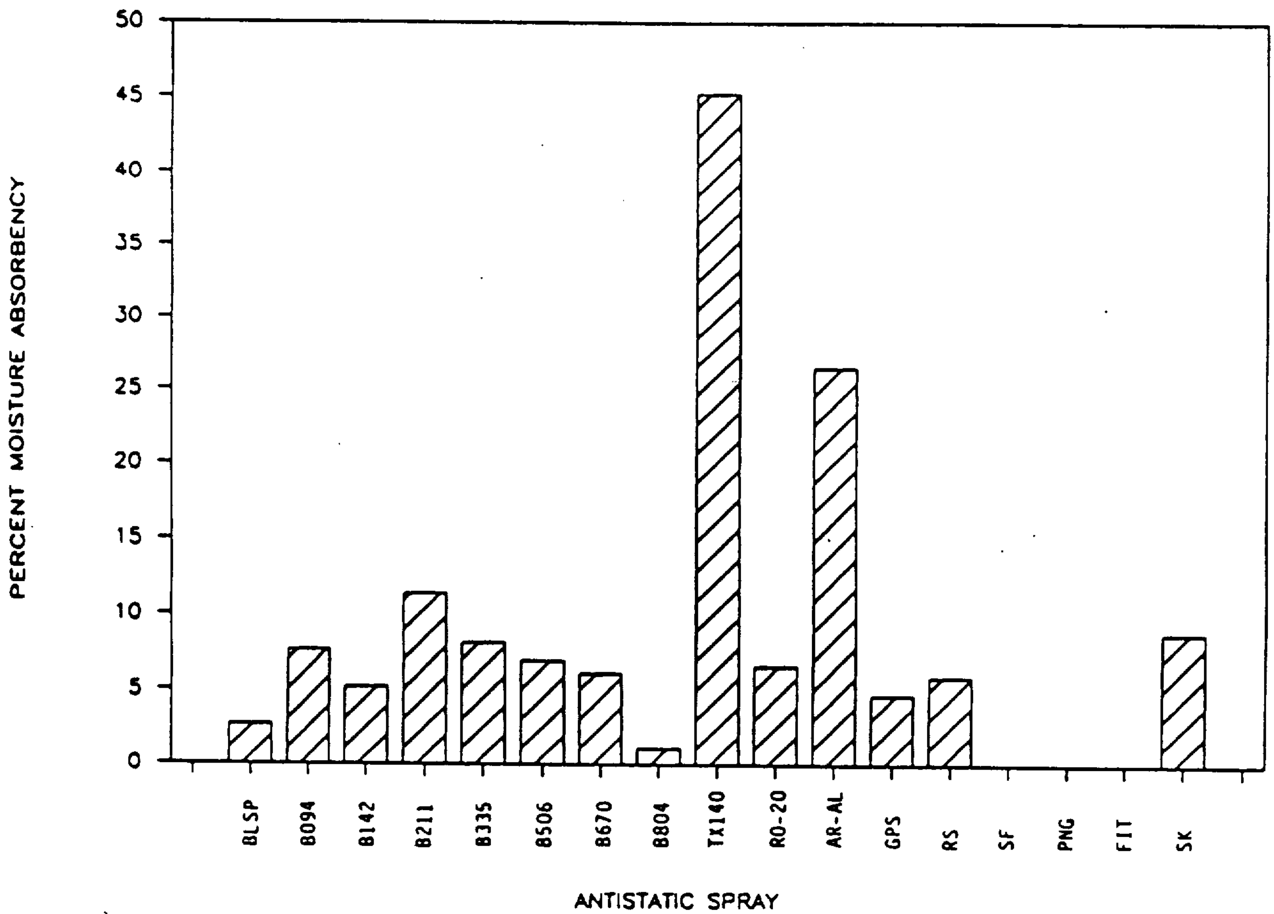

Figure 3. Percent Moisture Absorbency

ammonium chloride compound. Corrosion from these sprays can be from a reaction with the amine or ammonium chloride compound. The other sprays that do not corrode the aluminum contain amine, alcohol/glycol, and/or polyether/polyethoxylated compounds. Although some of these sprays also contain an amine they do not corrode the aluminum. These sprays contain a primary amine whereas the other more corrosive sprays contain a tertiary amine, which tends to be more basic.

Table 3. Corrosiveness

RATING	1	2	3	4	5
SAMPLE					
BLSP		X			
B094	X				
B142				X	
B211				X	
B335		X			
B506			X		
B670		X			
B804		X			
TX140					X
RO-20			X		
AR-AL					X
GPS				X	
RS				X	
SF	X				
PNG		X			
FIT	X				
SK			X		

1 = little or no effect
2 = slight fog
3 = moderate fog/slight corrosion
4 = moderate corrosion
5 = severe corrosion

ELECTROSTATIC PROPERTIES

The triboelectric testing instrument was used to examine the static charge accumulation and dissipation measurements. The plots obtained from the instrument give information on the peak voltage (the maximum voltage accumulated by the sample) and dissipation voltages as a function of time. Table 4 presents these values in a form similar to that used by Kennedy Space Center. (Figure 4 is a sample plot obtained by the triboelectric instrument.) The peak voltage of the samples indicates how effective an antistatic spray is at preventing charge accumulation. The dissipation measurements indicate the effectiveness of the sprays for bleeding off charges. An ideal antistatic spray should have a low peak voltage and fast dissipation rate. Both these measurements were obtained at 20, 40, and 60 percent relative humidity.

Table 4. Triboelectric Data

60% RELATIVE HUMIDITY

Voltage Discharge Rate

SAMPLE	PEAK	0.5sec	1sec	2sec	3sec	4sec	5sec
MYLAR	6500	6300	5800	5500	5300	5100	4800
BLSP	380	320	290	250	220	210	185
B094	810	800	720	520	400	320	270
B142	30	(STAYS AT 30)					
B211	620	450	330	185	120	74	50
B335	780	630	550	450	380	335	300
B506	40	(STAYS AT 40)					
B670	570	470	400	330	280	240	210
B804	80	50	40	30	25	20	15
TX140	45	(STAYS AT 45)					
RO-20	70	(STAYS AT 70)					
AR-AL	50	(STAYS AT 50)					
GPS	660	320	180	60	20	<20	
RS	20	(STAYS AT 20)					
SF	50	(STAYS AT 50)					
PNG	5000	4600	4200	3700	3300	2950	2700
FIT	3000	2800	2700	2650	2550	2450	2350
SK	20	(STAYS AT 20)					

Table 4. Triboelectric Data (continued)

40 % RELATIVE HUMIDITY

Voltage Discharge Rate

	SAMPLE	PEAK	0.5sec	1sec	2sec	3sec	4sec	5sec
BLSP	740	640	580	500	440	395	360	
B094	100	75	65	50	20	<20		
B142	40	-------------(STAYS AT 40)-----------						
B211	720	630	570	495	450	410	385	
B335	170	155	145	130	120	115	100	
B506	200	140	100	80	70	70	70	
B670	490	415	365	300	255	225	200	
B804	20	10	---------(STAYS AT 10)--------					
TX140	120	--------------(STAYS AT 120)----------						
RO-20	100	10	---------(STAYS AT 10)--------					
AR-AL	50	--------------(STAYS AT 50)-----------						
GPS	2400	1500	900	500	200	150	110	
RS	60	--------------(STAYS AT 60)-----------						
SF	80	--------------(STAYS AT 80)-----------						
PNG	3000	2600	2250	1800	1500	1300	1100	
FIT	4500	4200	4100	3800	3500	3000	2700	
SK	20	10	-----------(STAYS AT 10)--------					

Table 4. Triboelectric Data (continued)

20 % RELATIVE HUMIDITY

Voltage Discharge Rate

SAMPLE	PEAK	0.5sec	1sec	2sec	3sec	4sec	5sec
BLSP	120	55	30	20	<20		
B094	390	200	150	110	105	100	100
B142	300	------------(STAYS AT 300)-----------					
B211	80	60	55	50	45	45	45
B335	-----(OFF SCALE)------			600	350	200	110
B506	770	770	710	550	460	395	350
B670	100	25	<25				
B804	50	20	<20				
TX140	180	70	35	20	<20		
RO-20	-----(OFF SCALE)------			650	450	320	240
AR-AL	150	55	20	<20			
GPS	590	340	210	100	50	25	<25
RS	400	270	170	95	50	35	30
SF	100	------------(STAYS AT 100)------------					
PNG	------(OFF SCALE)-----			400	280	200	140
FIT	--------------------(OFF SCALE)------------------						
SK	10	<10					

All of the sprays except for PNG and FIT appeared to affect the static property of the Mylar film significantly. The peak voltage for the untreated Mylar film was around 6500 volts. For the PNG and FIT sprays, peak voltages were 5000 and 3000 respectively. The other sprays had peak voltages of 810 or less. SK had the lowest peak voltage, which was 20 volts. Although some of the sprays gave very low peak voltages, some of these sprays also had a slow voltage dissipation rate.

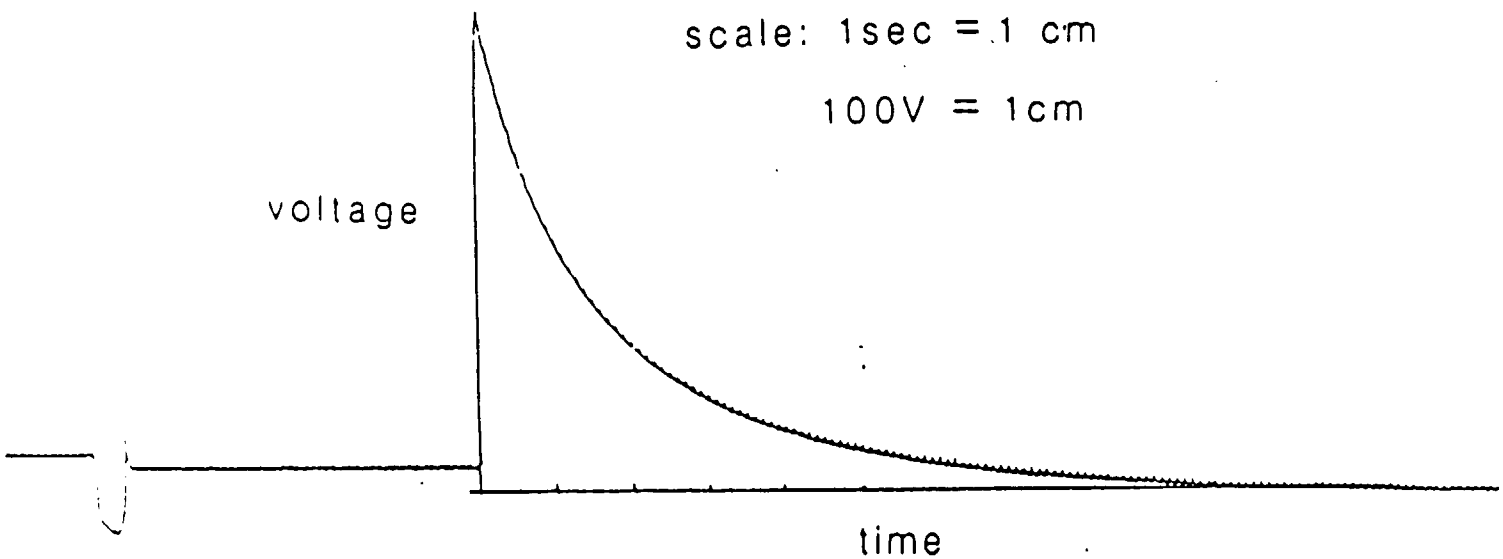

Figure 4. Sample Plot Obtained From the Triboelectric Instrument.

In general, sprays with a high percent moisture absorbency had a significant effect on the electrostatic properties. It appears that sprays with ammonium chloride compounds were also very effective. This may be from conductive ions from the ammonium chloride compound.

The effect of relative humidity can be observed for some samples. Most of the sprays become less effective as the humidity decreases. In certain instances, some sprays become more effective as the humidity decreases. This can be caused by the formation of ionic salts such as ammonium chloride.

CHEMICAL COMPOSITION

Information on the chemical composition of the antistatic sprays was provided by infrared spectrophotometry and mass spectrometry. Additional information on the ultraviolet characteristics was also obtained by ultraviolet spectrophotometry. Data from these analytical methods are presented in Tables 5, 6, and 7; this data can also be used to help identify an antistatic spray.

Table 5. Infrared Spectrophotometry Data

SAMPLE	ANALYSIS
BLSP	FATTY ACID ALKANOLAMINE/ ALKYL AMMONIUM CHLORIDE COMPOUND
B094	POLYAMINE & OTHER COMPOUNDS
B142	ETHOXYLATED FATTY ALCOHOL/AMINE
B211	ETHOXYLATED FATTY ALCOHOL/AMINE
B335	POSSIBLE ALKYLARYLSULFONATE COMPOUND/AMINE
B506	AMMONIUM CHLORIDE RELATED COMPOUND
B670	POLYETHOXYLATED AMMONIUM COMPOUND, ETHOXYLATED FATTY ALCOHOL, POLYALKOXYLATED ALKYLOL
B804	FATTY ACID ALKANOLAMIDE/ALKYL AMMONIUM CHLORIDE COMPOUND
TX140	ALKYL AMMONIUM CHLORIDE COMPOUND
RO-20	POSSIBLE ALCOHOL/GLYCOL RELATED COMPOUND, COCONUT OIL DERRIVATIVE

Table 5. Infrared Spectrophotometry Data (continued)

AR-AL	ALKYL AMMONIUM CHLORIDE COMPOUND
GPS	POSSIBLE ALCOHOL/GLYCOL RELATED COMPOUND, LONG CHAIN FATTY QUATERNARY AMMONIUM COMPOUND
RS	POSSIBLE ALCOHOL/GLYCOL RELATED COMPOUND, LONG CHAIN FATTY QUATERNARY AMMONIUM COMPOUND
SF	POSSIBLE FATTY ACID ALKANOAMINE COMPOUND
PNG	POLYETHOXYLATED AMMONIUM COMPOUND, ETHOXYLATED FATTY ALCOHOL, POLYALKOXYLATED ALKYLOL
FIT	METHYL ESTER COMPOUND
SK	POSSIBLE FATTY ACID ALKANOAMINE COMPOUND

Table 6. Mass Spectrometer Data

SAMPLE (TEMP.)	5 MOST INTENSE PEAKS	OTHER IMPORTANT PEAKS
BLSP (150 °C)	325,323,297,118,28	88,141,74,100,326
B094 (220 °C)	99,58,112,43,28	72,73,126,154
B142 (200 °C)	28,141,18,155,351	129,261,43,55
B211 (200 °C)	88,212,242,58,44	31,268,118,71,184
B335 (200 °C)	100,28,56,110,43	
(230 °C)	100,28,57,43,340	
B506 (200 °C)	212,58,240,268,43	296,394,352
B670 (200 °C)	31,28,45,18,29	
(230 °C)	28,45,18,64,89	73,99,262,308
B804 (150 °C)	324,298,118,88,325	100,74,43,28
TX140 (220 °C)	58,114,213,50,28	
RO-20 (210 °C)	211,88,58,43,28	239,267,70,183,156
AR-AL (190 °C)	58,212,72,50,43	
(250 °C)	58,28,43,69,83	
GPS (200 °C)	211,88,58,28,44	239,18,267,183,1

Table 6. Mass Spectrometer Data (continued)

RS	(200 °C)	213,88,58,44,28	240,269,185,157,70
SF	(150 °C)	74,28,56,141,30	
	(170 °C)	99,56,43,28,70	211,112,83
PNG	(180 °C)	28,45,43,29,18	89,73,57
FIT	(150 °C)	149,171,57,28,127	199,43,99,18,71
SK	(150 °C)	28,74,18,58,141	186,262,56
	(200 °C)	28,56,43,70,18	83,212,141,186,97

Table 7. Ultraviolet Transmission Loss

* Wavelengths shown indicate significant change in transmission

SAMPLE	WAVELENGTH* (nm)	LOSS OF TRANSMISSION (%)
BLSP	310	5
	280	14
	240	56
	210	100
B094	310	8
	280	11
	240	60
	230	100
B142	320	12
	290	18
	240	47
	210	72
B211	300	12
	270	18
	230	34
	210	47
B335	300	3
	260	9
	220	16
	210	21
B506	300	6
	270	12
	240	18
	210	30

Table 7. Ultraviolet Transmission Loss (continued)

SAMPLE	WAVELENGTH (nm)	LOSS OF TRANSMISSION (%)
B670	300	5
	260	12
	250	43
	240	85
B804	320	7
	280	15
	240	50
	220	100
TX140	310	10
	280	28
	240	45
	210	85
RO-20	320	15
	300	20
	250	35
	240	85
	230	100
AR-AL	290	5
	250	7
	230	22
	210	75
GPS	320	15
	270	40
	245	55
	235	75
	220	100
RS	320	15
	270	40
	245	55
	235	75
	220	100
SF	280	10
	260	45
	245	25
	230	65
	225	100
PNG	340	16
	330	44
	320	75
	310	100

Table 7. Ultraviolet Transmission Loss (continued)

SAMPLE	WAVELENGTH (nm)	LOSS OF TRANSMISSION (%)
FIT	N/A	N/A
SK	340	15
	320	50
	300	80
	280	100

Infrared spectrophotometry classified the sprays into several groups: amines, alcohols/glycols, polyethers/ polyethoxylated compounds, ammonium chloride compounds, and a methyl ester compound. Some of the sprays are mixtures of several compounds. Sprays with similar infrared patterns (which indicates that they have similar chemical composition) include PNG and B670, BLSP and B804, RO-20 and RS and GPS, TX140 and AR-AL, and SK.

Mass spectrometry, although not able to identify a specific compound, was useful for grouping the sprays into seven classes:

1) AR-AL and TX140 contain an amine compound.
2) SK contains a polyether and amine.
3) GPS,RS,RO-20,B506,and B211 may contain an ammonium chloride compound.
4) BLSP and B804 have similar compounds.
5) B142,B094,B335,and SF contain mixtures of amines.
6) B670 and PNG contain a polyether compound.
7) FIT contains a methyl ester compound.

This information also confirms some of the findings obtained by infrared analysis. Because the mass fragment patterns of the sprays did not match any of the reference patterns, an exact identification was not possible.

Ultraviolet spectrophotometry provided additional information to support some of the findings of infrared and mass spectrometry analysis. Sprays with similar ultraviolet characteristics include SK and PNG, RS and GPS, and B804 and BLSP.

CONCLUSION & RECOMMENDATIONS

Of the antistatic sprays examined, none fulfills all of the requirements of being low in contamination, noncorrosive, and electrostatically effective (i.e., having a low peak voltage and fast dissipation rate).

Sprays that are low in contamination (less than 1 percent NVR) include BLSP, B094, B142, B211, B335, B506, B804, AR-AL, GPS, SF, PNG, and FIT. Of these sprays, the BLSP, B094, B335, B804, SF, PNG, and FIT are also noncorrosive. From these sprays (which are both low in contamination and noncorrosive), only the B804 and SF gave low peak voltages (100 volts or less at the humidities examined). The problem with these two sprays is that they have a slow dissipation rate.

There are many possible applications for antistatic sprays by general industry. It is difficult to state that one particular spray is suitable for all applications. Each situation is different, and careful examination of the situation will help in the selection of an antistatic spray.

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15. Supplementary Notes

16. Abstract Antistatic sprays from several different manufacturers are examined. The sprays are examined for contamination potential (i.e., outgassing and nonvolatile residue), corrosiveness on an aluminum mirror surface, and electrostatic effectiveness. In addition, the chemical composition of the antistatic sprays is determined by infrared spectrophotometry, mass spectrometry, and ultraviolet spectrophotometry. The results show that 12 of the 17 antistatic sprays examined have a low contamination potential. Of these sprays, 7 are also noncorrosive to an aluminum surface. And of these, only 2 demonstrate good electrostatic properties with respect to reducing voltage accumulation; these sprays did not show a fast voltage dissipation rate however. The results indicate that antistatic sprays can be used on a limited basis where contamination potential, corrosiveness, and electrostatic effectiveness is not critical. Each application is different and proper evaluation of the situation is necessary. Information on some of the properties of some antistatic sprays is presented in this document to aid in the evaluation process.

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