

# THE FORENSIC VALUE OF DUCT TAPE COMPARISONS

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Trace evidence chemists are often asked to analyze and to compare all manner of commercial products that may associate a suspect to a victim. The value of this type of evidence is related to how variable the product is. The purpose of this paper is to show the variability of commercial duct tape: between manufacturers and within manufacturers and to thus establish its value as evidence. Additionally, I will describe those features which are most variable and thus should be examined first.

Fifty-one samples of duct tape were collected from random sources (see table 1). These fall within 8 different brand names and possibly 5 different manufacturers; Shuford-Mills (under Manco Inc. brand name), Anchor, Nashua, Tesa Tuck and Kendall.

Duct tape consists of three components; the film backing, the fabric and the adhesive. These components can vary between manufacturers and within manufacturers. Every company has a line of duct tape products to suit different needs as well as different budgets. Even within the same brand, same product code number, the tape can change due to differences in the suppliers, low bid components, availability of components etc.

## MACROSCOPIC EXAMS

The macroscopic exam of duct tape can yield a wealth of information and if the tapes for comparison are, in fact, different it will probably be noticeable at this level. Table 1 shows some of the initial exams. The scrim count (or yarn count) is predictive of the tape quality. The fabric of the tape is arranged in a loose (gauze) weave and has warp yarns (lengthwise or machine direction) and fill yarns (across). The scrim count is the number of warp and fill yarns in one square inch. The tape thickness can be measured by sticking the tape to a piece of glass and taking the difference between the glass and the glass and the tape. Although the roll may state a width of "50.8mm" it may be off up to a millimeter. Some manufacturers use "calendering" process to apply molten backing to the gauze and this appears on the film surface as small uniform pockets (Kendall tape). The shade of gray (aluminum powder) in the backing will vary only slightly if at all, but the single greatest variable in the macroscopic exam of duct tape will be the color of the adhesive. This color may also give you some clue as to the manufacturer of the tape. Shuford Mill is usually pale yellow-creamy white, Tesa Tuck and Anchor will be shades of light gray, Kendall may be darker gray to greenish gray etc.

## ADHESIVE CHARACTERISTICS

The color of the adhesive is variable because of the adhesive's complexity. It consists of rubber (usually natural rubber), resins, fillers, extenders, flame retardants, antioxidants etc. All of these components will vary to suit different user needs. The adhesive can be removed from a two square area of the tape with acetone or toluene and sonication. After drying, the weight of the adhesive can be the most useful physical measurement in discriminating between different tapes. The FTIR and elemental analysis of the adhesive will yield more information about the rubber and the fillers but is less discriminating. Analysis of 51 samples of tape (8 different brands, 5 different manufacturers) showed six different FTIR spectra and 10 different elemental groups. (Table 1.)

### Infrared absorption bands of common adhesive components (cm-1)

Polyterpene resins (tackifiers)	1450, 1374
Isoprene rubber	1450, 1374, 830
Synthetic polyterpene resin	1450, 1374, 1090
Aluminum silicate (China clay)	1110, 1031, 1007, 912
Titanium dioxide (broad peak)	800 - 450

Calcium sulfate	1160, 1120
Zinc Oxide (broad peak)	1250 - 1185

## FILM BACKING

After separating the fabric and adhesive it is easy to check the thickness of the backing. You may see more significant differences between manufacturers than within the same manufacturer. There is usually little to be gained by doing FTIR on the film backing since it is typically polyethylene. A small piece viewed under transmitted light may show some differences in microscopic appearance.

## FABRIC

The scrim count is best done before the tape is taken apart. The fabric is variable between and within manufacturers. (Table 2) However, typically the fibers will be polyester or blends of cotton and polyester (50/50 to 65/35). Again, little will be gained with FTIR of the fibers. The fiber information in Table 2 was gained on a polarized light microscope alone. Note from this table that the fill yarn fibers show more variability than the warp yarn fibers. In addition to these features examined in Tables 2, the fluorescence of the yarns can sometimes be discriminating where optical brighteners are present. Also, fill yarns may be texturized to give the tape bulk (Kendall products).

## CONCLUSIONS

The results in Table 1 and 2 and Figure 1 and 2 show the variability that may be expected between manufacturers and within the same manufacturer. Even among rolls of tape with the same product number differences may be found. Note tape #s 38 and 39, Manco Inc. Duck brand "Professional"; there is a difference in their fill yarn as well as a difference in their adhesive color (slightly different shades of pale yellow). Note also the variability in the adhesive formulas of Kendall-Polyken tape; four different FTIR spectra and six different elemental groupings among 16 different rolls. These observations support the conclusion that not all duct tapes are alike even when they have the same label. Therefore, comparison of questioned and known tapes can have a significant probative value when similar class characteristics are found. Consider that a roll of duct tape can last many years at one residence and that the construction, design, adhesive formulas and fabric of a given brand can change with each production line, possibly several times a year at any one plant. It becomes quite remote that a tape bought 10 years will be similar to anything bought today!

## ACKNOWLEDGMENTS:

I would like to acknowledge the help I received from Roger Keagy of the Federal Bureau of Investigation Laboratory, Washington D.C. in expanding my knowledge of this subject.

For a much more complete primer on duct tape construction and chemistry the reader is referred to the article by Mr. Hugh Snodgrass listed in the references

## REFERENCES:

1. Snodgrass, Hugh, Duct Tape Analysis as Trace Evidence, Proceedings of the International Symposium on the Forensic Aspects of Trace Evidence, F.B.I. Academy, Quantico, VA, p.69-73, June 1991
2. Benson, J. D., Forensic Examination of Duct Tape, Proceedings of the International Symposium on the Analysis and Identification of Polymers, F.B.I. Academy, Quantico VA., p.145-146, August 1984
3. Jenkins Jr., T. L., Elemental Examination of Silver Duct Tape Using Energy Dispersive X-Ray Spectrometry, Proceedings of the International Symposium on the Analysis and Identification of Polymers, F.B.I. Academy, Quantico Va., p.147-149, August 1984

Table 1

DUCT TAPE CONSTRUCTION AND ADHESIVE CHARACTERISTICS

ct#	BRAND NAME	Scrim Count	Tape	gray film	Tape	adhesive	adhesive	EDX	FTIR
		warp X fill	Thickness	Thickness	Width	color	weight-g	group	group
		(sq. inch)	ave.mils	ave.mils	(mm)		ln 2sq.cm		
36	Manco Inc. "The Original DUCK Tape" Cleveland, OH	30 x 19	10.5	2.6	50.8	pale yellow	0.082	4	1
38	MANCO Inc. "DUCK" Brand "Professional" Westlake, OH	24 x 16	8.9	2.7	50.8	pale yellow	0.069	4	1
41	MANCO Inc "DUCK Tape" Westlake, OH 1989	24 x 16	9.4	2.6	50.8	pale yellow	0.081	4	1
10	Manco "Duck" brand tape (Professional S-45)	24 x 15	10.1	3	49.8	pale yellow	0.068	4	1
39	MANCO "DUCK" Brand (Professional) Westlake, OH 1989	24 x 15	9	2.1	50.8	pale yellow	0.075	4	1
40	Manco Inc. "DUCK" Brand, Westlake OH 1989	24 x 15	9.4	2.4	50.8	pale yellow	0.077	4	1
1	Manco "DUCK" Brand Tape (CD-10)	24 x 14	9.4	2.6	50.8	pale yellow	0.07	1	1
6	Manco "DUCK" Brand Tape (CD-10)	24 x 14	9.2	2.6	50.8	pale yellow	0.063	2	1
7	Manco "DUCK" Brand Tape (CD-10)	24 x 14	9.4	2.5	50.8	pale yellow	0.069	2	1
8	Manco "DUCK" Brand Tape (CD-10)	24 x 14	9.3	2.6	50.8	off white	0.07	4	1
5	Manco "DUCK" Brand Tape (Professional), (S-10)	24 x 14	10.1	3.8	51.2	pale yellow	0.069	4	1
13	Manco Fire Guard Duct Tape (FD-30)	24 x 14	10.1	3.3	51.2	grayish gr	0.064	4	1
47	Manco Inc. for ACE (professional)	23 x 16	9.4	2.1	50.8	pale yellow	0.076	4	1
4	Manco The "Original DUCK" Tape	22 x 16	9.8	2.3	50.8	pale yellow	0.073	2	1
37	MANCO Inc. "DUCK" Brand	18 x 9	8	2.4	50.8	grayish gr	0.087	4	1
2	Manco The Original DUCK Brand Tape (B300)	18 x 9	9.4	4.6	49.8	pale yellow	0.058	2	1
49	MANCO Inc. "DUCK" Brand Tape 1992	18 x 9		3.2	51.8	pale yellow	0.085	4	1
14	Manco Utility Duct Tape (DX-450)	18 x 9	7.4	1.9	50.8	pale yellow	0.049	2	1
12	Manco "DUCK" Brand Tape	18 x 9	8.6	2.8	51.2	pale yellow	0.058	4	1
11	Manco Inc. for ACE "Duck" (ACE 42897)	18 x 9	8.9	2.7	50.8	pale yellow	0.076	2	1
35	Manco Utility Duct Tape (DX-450)	18 x 8	9.1	2.4	50.8	pale yellow	0.068	4	1
3	3M Tartan Brand Cloth Tape, (300 MPH Club)	19 x 9	7.7	2	50.8	gray	0.037	3	2
16	3M Tartan Cloth Duct Tape Contractor Grade	19 x 9	7.6	1.9	49.8	gray	0.058	7	2
32	3M TARTAN brand Duct Tape	18 x 8	8.3	1.9	50.8	grayish gr	0.071	3	2
9	PERFORMER Duct Tape for K-Mart Corp.	17 x 9	8.6	2.3	50.8	gray	0.056	3	2
15	Anchor Continental Inc. Duct Tape Premium Grade	20 x 12	9.7	2.8	51.2	gray	0.065	3	2
23	POLYKEN Duct tape	42 x 27	13	2.7	49.8	grayish gr	0.1	10	3
19	Polyken Duct Tape (231)	41 x 19	11.6	6.2	49.8	pale yellow	0.062	9	4
20	POLYKEN Duct tape	30 x 26	12.3	6.6	49.8	pale yellow	0.062	7	4
45	POLYKEN The Kendall Co. Boston, MA	30 x 16	12.5	6.2	50.8	grayish gr	0.045	4	1
26	POLYKEN Duct tape	30 x 14	11	2.6	50.8	grayish gr	0.096	8	3
34	POLYKEN Duct tape (235)	29 x 14	12.8	2.5	51.8	grayish gr	0.109	7	1
17	POLYKEN Duct tape (227)	20 x 14	11.3	6.4	50.2	grayish gr	0.058	8	3
33	KENDALL Co. Tape	20 x 14	9.2	5.5	50.8	grayish gr	0.043	7	1
25	POLYKEN Duct tape (203)	20 x 13	9	5.6	50.8	grayish gr	0.034	8	3
18	POLYKEN Duct tape (217)	20 x 10	8.3	4.4	51.2	grayish gr	0.044	8	3
24	POLYKEN Duct tape (228)	20 x 10	10.8	2.3	50.8	grayish gr	0.092	8	3
22	POLYKEN Duct tape (223)	19 x 14	9.9	6.7	50.2	blue gray	0.054	8	3
27	POLYKEN Duct tape (229)	19 x 14	11.7	6.2	50.8	gray	0.06	8	3
28	POLYKEN Duct tape	19 x 10	8	5.9	50.2	grayish gr	0.03	8	3
21	POLYKEN Duct tape (243)	19 x 9	9.8	2.8	50.8	grayish gr	0.076	10	3
51	KENDALL-POLYKEN Duct Tape	19 x 7	7.4	2.7	49.2	blue gray	0.042	12	6
48	TUCK Tape New Rochelle, NY	24 x 18	8.6	2.2	50.8	light gray	0.065	11	1
29	TESA TUCK General Purpose (UPS label 7617821411)	22 x 9	7.7	2.4	48.8	blue gray	0.05	10	3
46	TESA TUCK Inc. TUCK Brand	19 x 9	7.2	2.4	51.8	blue gray	0.045	10	3
53	TESA TUCK Duct Tape	18 x 9		2.2	50.8	light gray	0.046	10	3
31	No Brand from Crocker, MO	19 x 11	7.3	3.9	50.8	light gray	0.041	7	1
42	L-121160 #9 Unknown	19 x 10	8.6	1.9	49.8	gray	0.069	3	2
43	L-121160 #1 Piece of Duct tape from Roll	24 x 15	9.1	2.1	51.8	pale yellow	0.073	4	1
44	L-125444#1	18 x 9	8.5	2.2	38.2	pale yellow	0.074	4	1
50	No Brand from Firearms I.D.	19 x 10		2.4	50.8	gray	0.092	11	5
52	NASHUA 398 Duct Tape	22 x 10		3.4	51.2	grayish gr	0.081	8	3

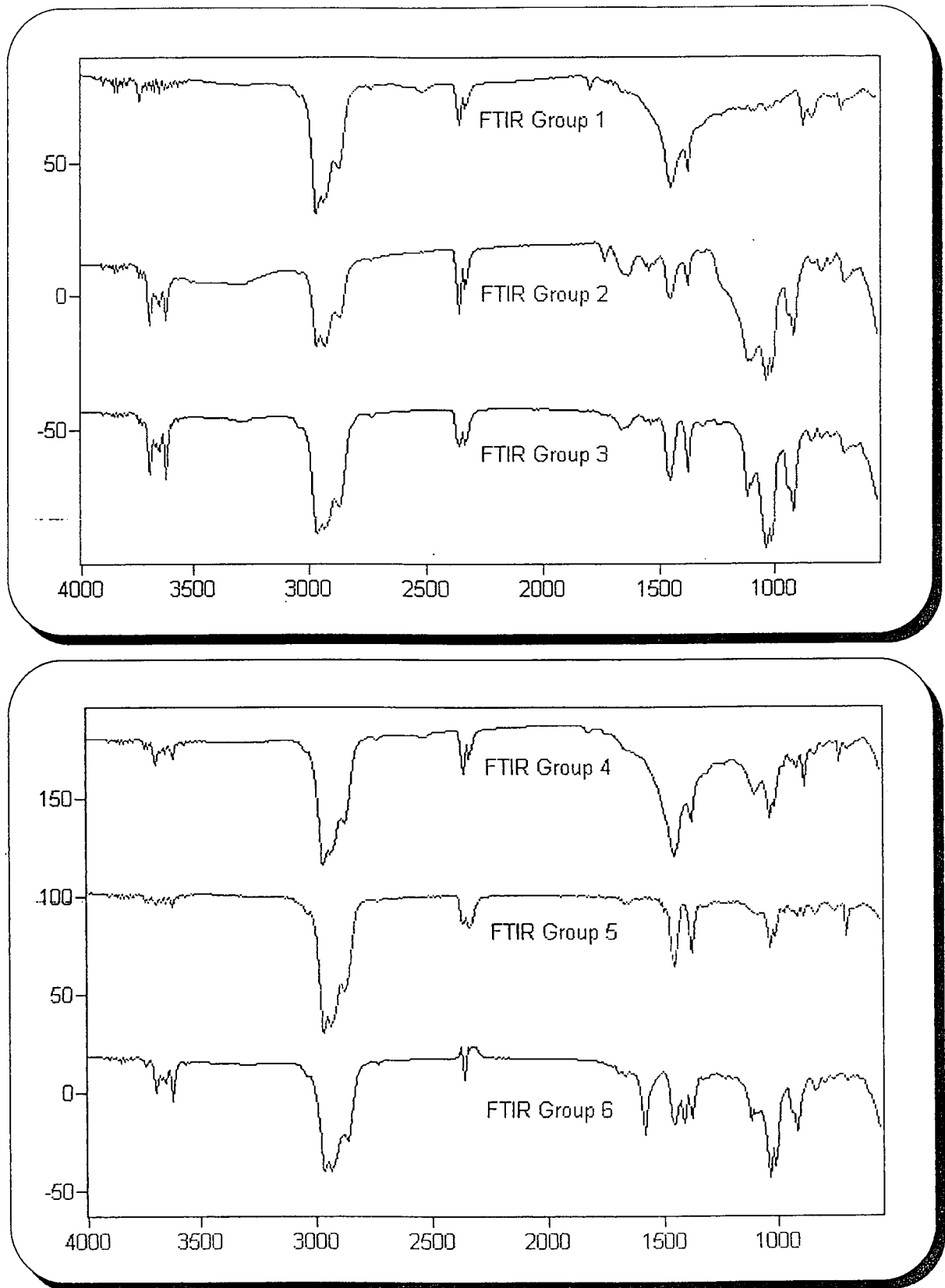
Table 2

DUCT TAPE FILL AND WARP YARN CHARACTERISTICS

ct#	BRAND NAME	Fill Yarn	Fill Yarn	Fill Yarn	Fill Yarn	Warp Yarn	Warp Yarn	Warp Yarn	Warp Yarn
		diameter (um)	shape	delustering	blended w.cotten?	diameter (um)	shape	delustering	blended w.cotten?
36	Manco Inc. "The Original DUCK Tape" Cleveland, OH	13	round	moderate	yes	13	round	moderate	yes
38	MANCO Inc. "DUCK" Brand "Professional" Westlake,	18	trilobal	light	no	13	round	moderate	yes
41	MANCO Inc "DUCK Tape" Westlake, OH 1989	18	trilobal	light	no	15	irreg round	light	yes
10	Manco "Duck" brand tape (Professional S-45)	23	round	heavy	no	13	round	moderate	yes
39	MANCO "DUCK" Brand (Professional) Westlake, OH	23	round	heavy	no	13	round	moderate	yes
40	Manco Inc. "DUCK" Brand, Westlake OH 1989	25	round	heavy	no	15	irreg round	light	yes
1	Manco "DUCK" Brand Tape (CD-10)	25	trilobal	light	no	13	round	moderate	yes
6	Manco "DUCK" Brand Tape (CD-10)	23	trilobal	light	no	13	round	moderate	yes
7	Manco "DUCK" Brand Tape (CD-10)	25	round	heavy	no	13	round	moderate	yes
8	Manco "DUCK" Brand Tape (CD-10)	23	irreg.round	light	no	13	round	moderate	yes
5	Manco "DUCK" Brand Tape (Professional), (S-10)	23	round	moderate	no	13	round	moderate	yes
13	Manco Fire Guard Duct Tape (FD-30)	23	round	heavy	no	13	round	moderate	yes
47	Manco Inc. for ACE (professional)	13	round	moderate	yes	13	irreg round	light	yes
4	Manco The "Original DUCK" Tape	13	round	light	yes	13	round	light	yes
37	MANCO Inc. "DUCK" Brand	23	round	absent	no	13	round	moderate	yes
2	Manco The Original DUCK Brand Tape (B300)	25	trilobal	light	no	13	round	moderate	yes
49	MANCO Inc. "DUCK" Brand Tape 1992	20	triangular	moderate	yes	13	round	moderate	yes
14	Manco Utility Duct Tape (DX-450)	23	round	heavy	no	13	round	moderate	yes
12	Manco "DUCK" Brand Tape	23	round	heavy	no	13	round	moderate	yes
11	Manco Inc. for ACE "Duck" (ACE 42897)	23	round	heavy	no	13	round	moderate	yes
35	Manco Utility Duct Tape (DX-450)	23	round	heavy	no	13	round	moderate	yes
3	3M Tartan Brand Cloth Tape, (300 MPH Club)	13	irreg.round	moderate	yes	33	5-sided	heavy	no
16	3M Tartan Cloth Duct Tape Contractor Grade	13	irreg.round	moderate	yes	33	5-sided	heavy	no
32	3M TARTAN brand Duct Tape	13	irreg.round	moderate	yes	33	5-sided	heavy	no
9	PERFORMER Duct Tape for K-Mart Corp.	13	irreg.round	moderate	yes	33	5-sided	heavy	no
15	Anchor Continental Inc. Duct Tape Premium Grade	33	5-sided	heavy	no	13	round	moderate	yes
23	POLYKEN Duct tape	13	round	moderate	yes	13	round	moderate	yes
19	Polyken Duct Tape (231)	33	5-sided	heavy	no	13	round	moderate	yes
20	POLYKEN Duct tape	13	round	moderate	yes	13	round	moderate	yes
45	POLYKEN The Kendall Co. Boston, MA	33	5-sided	heavy	no	13	round	light	yes
26	POLYKEN Duct tape	13	round	moderate	yes	13	round	moderate	yes
34	POLYKEN Duct tape (235)	15	round	light	yes	13	round	light	yes
17	POLYKEN Duct tape (227)	33	5-sided	heavy	no	13	round	moderate	yes
33	KENDALL Co. Tape	33	5-sided	heavy	no	13	round	light	yes
25	POLYKEN Duct tape (203)	33	5-sided	heavy	no	13	round	moderate	yes
18	POLYKEN Duct tape (217)	33	5-sided	heavy	no	13	round	moderate	yes
24	POLYKEN Duct tape (228)	33	5-sided	heavy	no	13	round	moderate	yes
22	POLYKEN Duct tape (223)	33	5-sided	heavy	no	13	round	moderate	yes
27	POLYKEN Duct tape (229)	33	5-sided	heavy	no	13	round	moderate	yes
28	POLYKEN Duct tape	33	5-sided	heavy	no	13	round	moderate	yes
21	POLYKEN Duct tape (243)	33	5-sided	heavy	no	13	round	moderate	yes
51	KENDALL-POLYKEN Duct Tape	33	5-sided	heavy	no	13	round	moderate	yes
48	TUCK Tape New Rochelle, NY	15	irreg.round	light	yes	13	round	light	yes
29	TESA TUCK General Purpose (UPS label 76178214)	18	round	light	yes	13	round	moderate	yes
46	TESA TUCK Inc. TUCK Brand	33	5-sided	heavy	no	13	round	moderate	yes
53	TESA TUCK Duct Tape	33	5-sided	heavy	no	13	round	moderate	yes
31	No Brand from Crocker, MO	33	5-sided	heavy	no	13	round	light	yes
42	L-121160 #9 Unknown	13	round	moderate	yes	13	irreg.round	moderate	yes
43	L-121160 #1 Piece of Duct tape from Roll	20	trilobal	light	no	13	round	moderate	yes
44	L-125444#1	23	trilobal	light	no	13	round	moderate	yes
50	No Brand from Firearms I.D.	13	irreg.round	light	yes	13	round	light	yes
52	NASHUA 398 Duct Tape	13	round	moderate	yes	10	round	moderate	yes

Figure 1

INFRARED SPECTRA OF DUCT TAPE ADHESIVE



Of 51 duct tape samples from 4 different manufacturers, distributed under 8 brand names, there were 6 different FTIR spectra that were developed. The group number by each different scan type correspond to FTIR group # listed by each sample in table 1.

Figure 2

### ENERGY DISPERSIVE X-RAY OF DUCT TAPE ADHESIVES

Elemental analysis of the adhesive of 51 duct tapes (4 different manufacturers distributed under 8 different brand names) showed 10 different elemental groupings. The group into which each sample of tape falls is given in table 1.

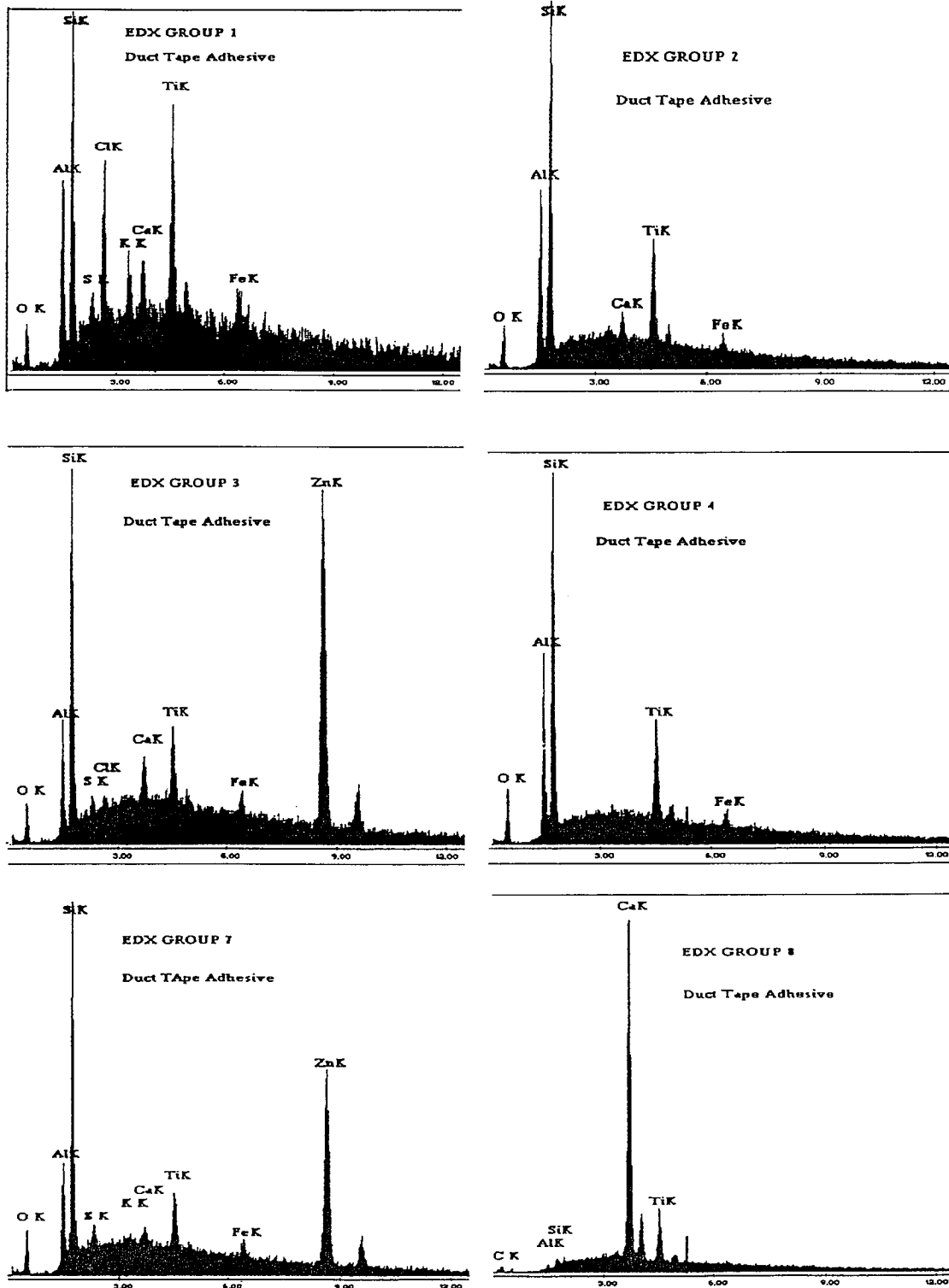


Figure 2

EDX groupings of duct tape adhesives, continued:

