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A Better Measure.

Adhesiveness of Tape via Nanoindentation

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INTRO:

The effectiveness of tape is determined by its cohesive and adhesive abilities. Cohesion is defined as the tape's internal strength while adhesion is the tape's ability to bond to its interacting surface. The adhesion of tape is influenced by numerous factors, such as exerted pressure, surface energy, molecular forces, and surface texture [1]. To quantify adhesion of tapes, nanoindentation with the Nanovea Mechanical Tester's Nano Module can be conducted to measure the work required to separate the indenter from the tape.

IMPORTANCE OF QUANTIFYING ADHESION OF TAPE WITH NANOINDENTATION

Replicating real life situation, such as skin and band-aid or tire and asphalt interaction, can be quite important for quality control or R&D research. The Nanovea Mechanical Tester can accommodate to create ideal condition with its ability to output normal forces below 1mN and up to 200N. Environmental testing can also be conducted with humidity, temperature, and lubrication modules. This can be used to find optimal conditions for maximizing adhesion or to find factors that limit the effectiveness of the adhesive.

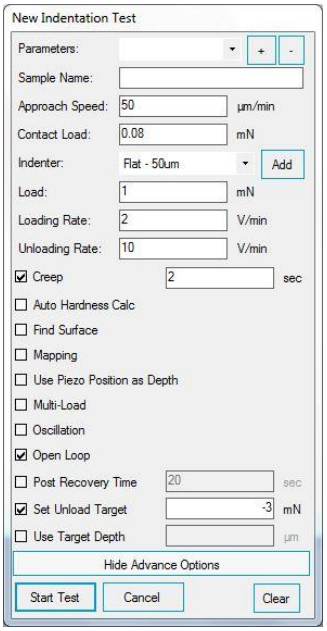
MEASUREMENT OBJECTIVE

The adhesion of three type of adhesive tapes were quantified using Nanovea's Mechanical Tester's Nano Module. By indenting in the sample, the sample will stick onto the indenter surface and apply a negative force when the indenter is raised above the sample surface. Eventually, the distance between the sample and the indenter will be too great and the indenter will separate from the sample, leaving a near-zero force reading. The negative force region is used to quantify adhesion since it is caused by the tape "holding onto" the indenter.

TEST CONDITIONS & PROCEDURES

The following indentation parameters were used:

	All Samples
Maximum Force (mN)	1
Loading Rate (V/min)	2
Unloading Rate (V/min)	10
Creep (s)	2
Indenter Type	Flat
Indenter Radius (um)	50



The loading rate of 10 V/min is approximately 200µm/min.

It is important to note that the numbers obtained are heavily related to the indentation parameters set. Changing the amount of pressure applied into the sample, how long the indenter is in the sample, or how fast the indenter is removed can change the adhesive properties.

RESULTS:

Below is a summary of results from the nanoindentation tests conducted on three different tape samples. The work was calculated by integrating the region where the load was negative. The work is representative of how much energy is required to completely separate the tape and the indenter.

Tape #	Maximum Negative Force (mN)	Work (nJ)
1	0.960 ± 0.105	101.30 ± 11.26
2	0.438 ± 0.013	32.24 ± 3.24
3	0.343 ± 0.018	11.23 ± 1.77

Tape 1:

Test	Maximum Negative Load (mN)	Work (nJ)
1	1.137	120.07
2	0.962	105.99
3	0.992	100.06
4	0.871	87.89
5	0.837	92.45
Average	**0.960**	**101.29**
Standard Deviation	**0.105**	**11.26**

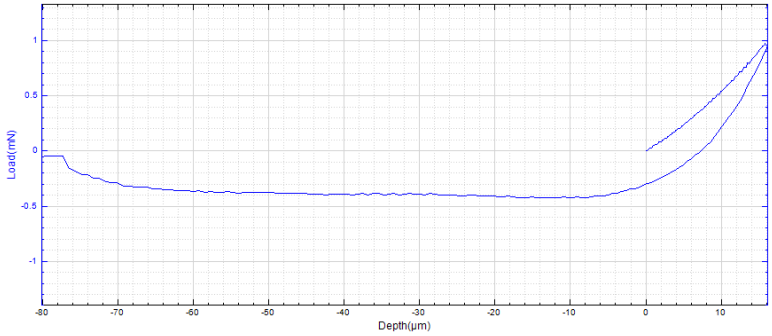


Figure 1: Load vs Depth for Tape 1

Tape 2:

Test	Maximum Negative Load (mN)	Work (nJ)
1	0.436	32.13
2	0.452	36.45
3	0.427	29.84
4	0.453	35.08
5	0.422	27.68
Average	**0.438**	**32.24**
Standard Deviation	**0.013**	**3.24**

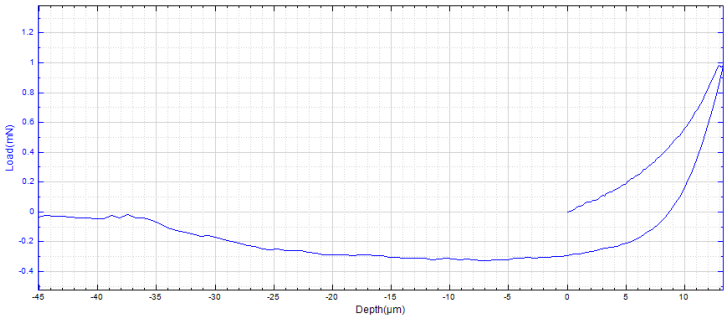


Figure 2: Load vs Depth for Tape 2

Tape 3:

Test	Maximum Negative Load (mN)	Work (nJ)
1	0.330	10.29
2	0.330	11.04
3	0.339	11.26
4	0.379	14.44
5	0.338	9.11
Average	**0.343**	**11.23**
Standard Deviation	**0.018**	**1.77**

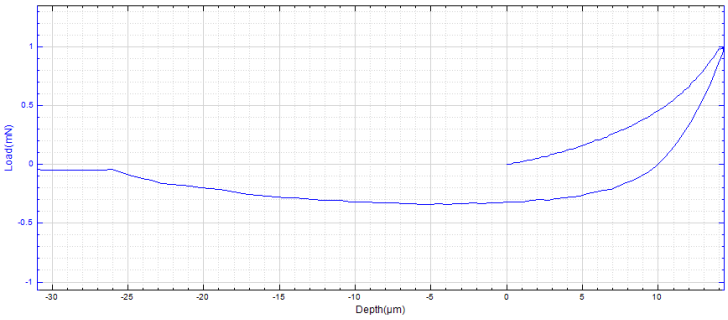


Figure 3: Load vs Depth for Tape 3

DISCUSSION:

All three tapes displayed different adhesive strengths. Tape 1 was significantly stronger than tape 2 and 3. The work required to remove the Tapes 1, 2, and 3 were 101.29 ± 11.26, 32.24 ± 3.24, and 11.23 ± 1.77 nJ respectively. While the standard deviation is quite large (possibly due to surface contaminants and inhomogeneous surfaces), the numbers obtained are distinct. This shows that the Nanovea Mechanical Tester Nano Module was able to successfully find differences in adhesion between three tape samples.

CONCLUSION:

With the Nanovea Mechanical Tester's Nano Module, the adhesion of three different tape samples were obtained. The samples had distinct adhesion properties and can be ranked from strongest to weakest adhesion: Tape 1, Tape 2, and Tape 3. This type of testing is applicable to all types of material (e.g. biological, polymers, and others) as long as the material can adhere to its opposing surface. With the Nanovea Mechanical Tester's ability to sense forces below 1mN, it can even perform very sensitive measurements for unique applications.

References:

[1] *"What exactly is the physical or chemical process that makes adhesive tape stick?"* Scientific America, https://www.scientificamerican.com/article/what-exactly-is-the-physi/