TESTING OF VARIOUS POLYMER FILMS AND BASIC

PROJECT
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DESCRIPTION OF TESTS PERFORMED

Tensile Strength Test

Scope:

Tensile tests measure the force required to break a specimen and the extent to which the specimen stretches or elongates to that breaking point. Tensile tests produce a stress-strain diagram, which is used to determine tensile modulus. The data is often used to specify a material, to design parts to withstand application force and as a quality control check of materials. Since the physical properties of many materials (especially thermoplastics) can vary depending on ambient temperature, it is sometimes appropriate to test materials at temperatures that simulate the intended end use environment.

Test Procedure:

Specimens are placed in the grips of the Instron at a specified grip separation and pulled until failure. For ASTM D638 the test speed is determined by the material specification. For ISO 527 the test speed is typically 5 or 50mm/min for measuring strength and elongation and 1mm/min for measuring modulus. An extensometer is used to determine elongation and tensile modulus.

Elevated or Reduced Temperature Test Procedure:

A thermal chamber is installed on the Instron universal test machine. The chamber is designed to allow the test mounts from the base and crosshead of the Instron to pass through the top and bottom of the chamber. Standard test fixtures are installed inside the chamber, and testing is conducted inside the controlled thermal environment the same as it would be at ambient temperature. The chamber has internal electric heaters for elevated temperatures and uses external carbon dioxide gas as a coolant for reduced temperatures. The size of the chamber places a limitation on the maximum elongation that can be reached, and extensometers are generally limited to no more than 200° C.

Equipment Used:

- Universal Testing Machine (UTM)
- Extensometers

Calculation of Tensile Strength:

$$\boxed{T.S. = F/A}$$

where, T.S.= Tensile Strength (kg f/mm^2)

F= Force required to break the sample (kg f)

A= Area of cross-section of sample (mm^2)

TEAR TEST

Scope:

Tear resistance measures the ultimate force required to tear film or sheet. It is often used for quality control checks or for material comparison where tear failures are possible.

Test Procedure:

The average thickness of the specimen is measured. The specimen is then placed in the grips of the testing machine and pulled at a rate of 2 in. per minute (for ASTM D1004) until rupture.

Specimen Size:

The specimen is die cut to the appropriate shape from a sheet. The shape of the specimen is designed to create a tear when the specimen is pulled in tension. Die C specimens are commonly used.

Equipments Used:

- Universal Tester
- Air grips or Roller grips
- Die cutters

Calculation of Tear Strength:

$$\boxed{T.S. = F/D}$$

where, T.S. = Tear Strength (kg f/mm)

F = Force required tear the sample (kg f)

D = Thickness of the sample (mm)

BURST TEST

Scope:

Burst Test is required to test the burst strength of the sample under observation. The burst strength is a measure of the load required under which the failure takes place. It is often used for quality control checks or for material comparison where failures are possible.

Test Procedure:

The specimen is placed between two concentric circular plates of the tester. Both the plates has a circular void in the middle through which a rod can push the film at a predefined rate and the maximum load required to produce failure is noticed. The load is expressed in kilogram force.

Equipments Used:

- Universal Tester

Dielectric Strength Test

Scope:

Dielectric Strength is a measure of the electrical strength of a material as an insulator. Dielectric strength is defined as the maximum voltage required to produce a dielectric breakdown through the material and is expressed as Volts per unit thickness. The higher the dielectric strength of a material the better its quality as an insulator.

Test Procedure:

There are three basic procedures that can be used to determine the dielectric strength of an insulator. These procedures are the short-time method, the slow rate-of-rise method and the step-by-step method. Each of these three methods has the same basic set-up, which consists of the test specimen placed between two electrodes in air or oil.

For the most common test, the short-time method, voltage is applied across the two electrodes and raised from zero to dielectric breakdown at a uniform rate. Breakdown is when an electrical burn-through punctures the sample, or decomposition occurs in the specimen. The rate of voltage rise is determined by the time it takes the sample to reach dielectric breakdown.

The slow-rate-of rise method starts at 50% of the breakdown voltage as determined by the short-time-method and is increased at a uniform rate.

The step-by-step method starts at 50% of the short-time-test then voltage is increased at equal increments for a specified time period until breakdown. The test is sometimes performed in oil to prevent arcing from the electrode to the ground.

Specimen size:

The recommended specimen type for this test is a 4 inch plaque or larger. Any specimen thickness can be used, however the most common thickness is between 0.8 to 3.2 mm (0.032 to 0.125 inch). Specimens over 2 mm thick are typically tested in oil to decrease the chance of flashover before breakdown.

Data:

Dielectric strength is calculated by dividing the breakdown voltage by the thickness of the sample. The data is expressed in Volts/mil. The location of the failure is also recorded. A higher dielectric strength represents a better quality of insulator.

Equipment Used:

- Hipotronics Dielectric Test Set
- Electrodes

Calculation of Dielectric Strength:

$$\boxed{D.S. = V/D}$$

where, D.S. = Dielectric Strength (kV/mm)

V = Breakdown Voltage (kV)

D = Thickness of the sample (mm)

PROCEDURE

Tests Performed:

1. Tensile Strength Test
2. Tear Test
3. Burst Test
4. Dielectric Strength Test

Conditions under which tests performed:

1. Polymer film taken fresh at room temperature
2. Polymer film dipped in 1N HCl, 3N HCl & 3N NaOH at room temperature for 1 week at room temperature
3. Polymer film dipped in 1N HCl, 3N HCl & 3N NaOH at room temperature for 2 weeks at room temperature
4. Polymer film dipped in 1N HCl, 3N HCl & 3N NaOH at room temperature for 3 weeks at room temperature

Procedure:

1. First of all, one sample of polymer film is cut in shape required for each of the four tests.
2. Then cut 9 more symmetrical pieces of each shape for the 10 similar tests to be conducted on the polymer film.
3. Repeat the above two steps for the other two polymer films.
4. Now take one piece cut of each of the polymer sample for a certain test. Perform the test on them and note the observations.
5. Similarly perform all the other 3 tests and note all the observations.
6. Now prepare a 1N HCl, a 3N HCl and a 3N NaOH solution.
7. Divide all the 3 sample pieces symmetrically and dip them fully in the solutions prepared above. Mark the beakers with the solution name and its strength.
8. After 1 week time, perform all the tests once on the 3 polymer samples and note the results.
9. Similarly, do the above step after 2nd and 3rd week, and note all the results.
10. Tabulate the results and compare them graphically.

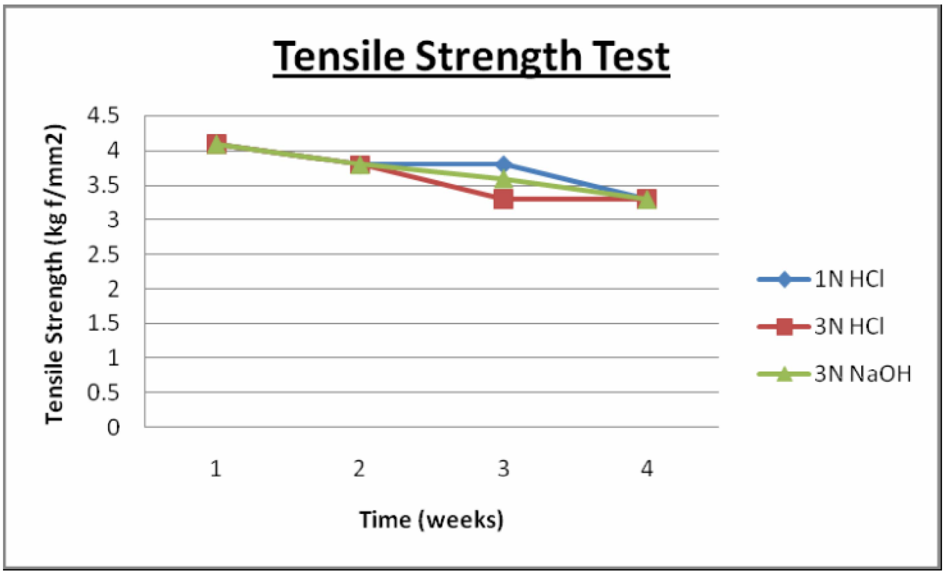
OBSERVATIONS

Sample 1

Tensile Strength Test

Time Period	1N HCl				3N HCl				3N NaOH			
	L (mm)	ΔL (mm)	Wt. (kg)	T.S. (kg f/mm^2)	L (mm)	ΔL (mm)	Wt. (kg)	T.S. (kg f/mm^2)	L (mm)	ΔL (mm)	Wt. (kg)	T.S. (kg f/mm^2)
0 weeks	150	319.4	1.6	4.1	150	319.4	1.6	4.1	150	319.4	1.6	4.1
1 weeks	150	301.5	1.5	3.8	150	302.0	1.5	3.8	150	301.2	1.5	3.8
2 weeks	150	296.8	1.5	3.8	150	271.5	1.3	3.3	150	309.8	1.4	3.6
3 weeks	150	274.0	1.3	3.3	150	265.3	1.3	3.3	150	275.5	1.3	3.3

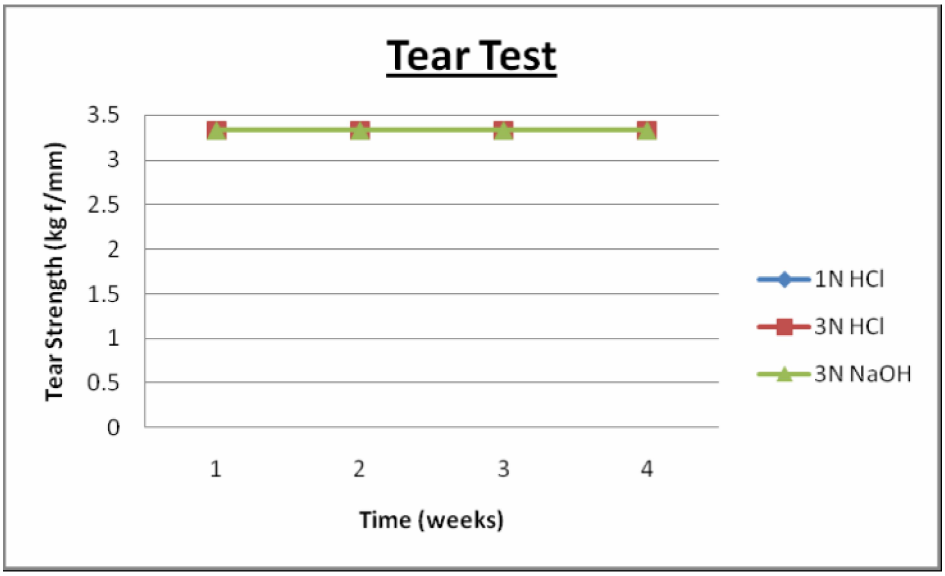
Thickness of sample = 0.03 mm



Tear Test

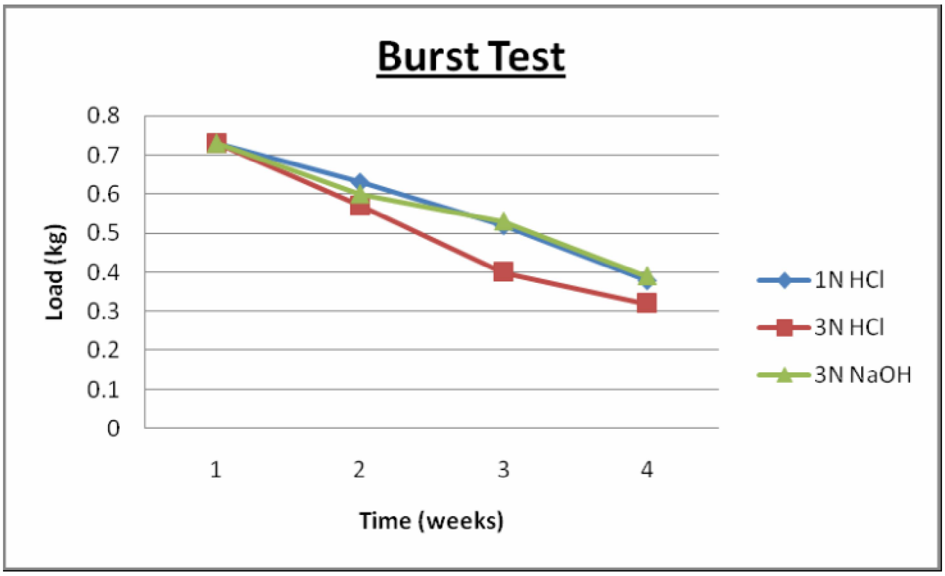
Time Period	1N HCl		3N HCl		3N NaOH	
	Max. Load (kg)	Tear Strength (kg/mm)	Max. Load (kg)	Tear Strength (kg/mm)	Max. Load (kg)	Tear Strength (kg/mm)
0 weeks	0.1	3.33	0.1	3.33	0.1	3.33
1 weeks	0.1	3.33	0.1	3.33	0.1	3.33
2 weeks	0.1	3.33	0.1	3.33	0.1	3.33
3 weeks	0.1	3.33	0.1	3.33	0.1	3.33

Thickness of Specimen = 0.03 mm



Burst Test

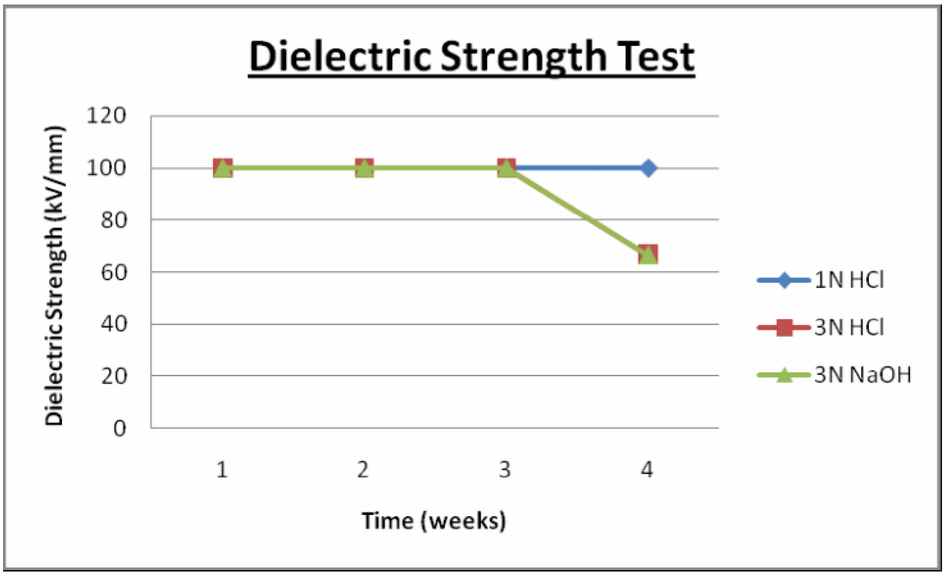
Time Period	1N HCl	3N HCl	3N NaOH
	Load (kg)	Load (kg)	Load (kg)
0 weeks	0.73	0.73	0.73
1 weeks	0.63	0.57	0.60
2 weeks	0.52	0.40	0.53
3 weeks	0.38	0.32	0.39



Dielectric Test

Time Period	1N HCl		3N HCl		3N NaOH	
	Voltage (kV)	D.S.(kV/mm)	Voltage (kV)	D.S.(kV/mm)	Voltage (kV)	D.S.(kV/mm)
0 weeks	3	100	3	100	3	100
1 weeks	3	100	3	100	3	100
2 weeks	3	100	3	100	3	100
3 weeks	3	100	2	66.67	2	66.67

Thickness of Specimen = 0.03 mm



Result

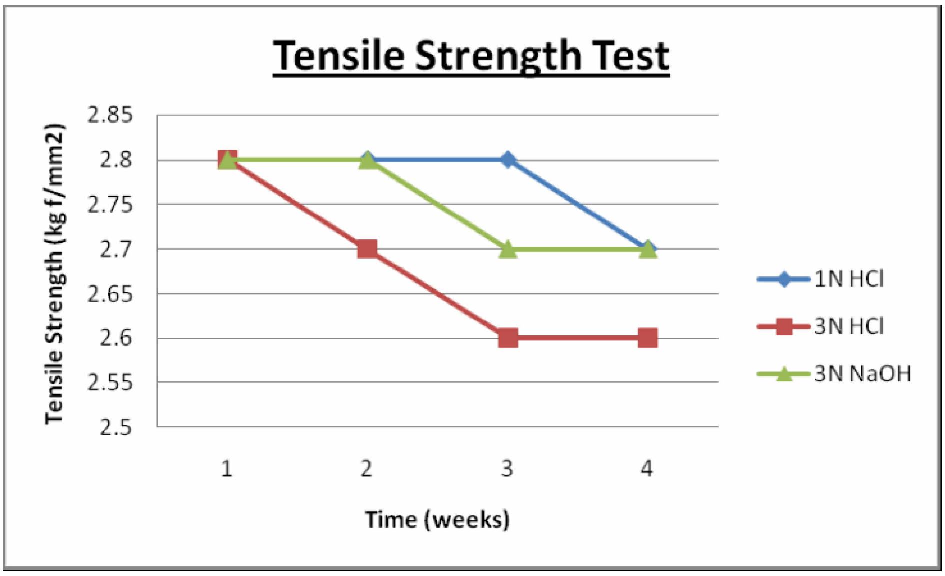
It can be seen that there is degradation in the mechanical and electrical properties of the PS sample used. This deterioration increases with the acidic/basic strength or with the time. The most probable cause for this decrease in properties can be that when the polymer comes in contact with acid or base, the intermolecular and intramolecular bonds tends to break. Due to this breaking of bonds the mechanical strength decreases with time for same acid or it decreases with increasing acidic strength. Moreover there can be one more reason for this degradation, i.e., hydrolysis. Although in general, vinyl polymers are not susceptible to hydrolysis and polystyrene is also resonance stabilized to it has even less tendency to hydrolyze.

Sample 2

Tensile Strength Test

Time Period	1N HCl				3N HCl				3N NaOH			
	L (mm)	ΔL (mm)	Wt. (kg)	T.S. (kg f/mm^2)	L (mm)	ΔL (mm)	Wt. (kg)	T.S. (kg f/mm^2)	L (mm)	ΔL (mm)	Wt. (kg)	T.S. (kg f/mm^2)
0 weeks	150	12.8	2.2	2.8	150	12.8	2.2	2.8	150	12.8	2.2	2.8
1 weeks	150	12.4	2.2	2.8	150	11.9	2.1	2.7	150	12.2	2.2	2.8
2 weeks	150	12.1	2.2	2.8	150	11.2	2.0	2.6	150	11.7	2.1	2.7
3 weeks	150	11.6	2.1	2.7	150	10.7	2.0	2.6	150	11.3	2.1	2.7

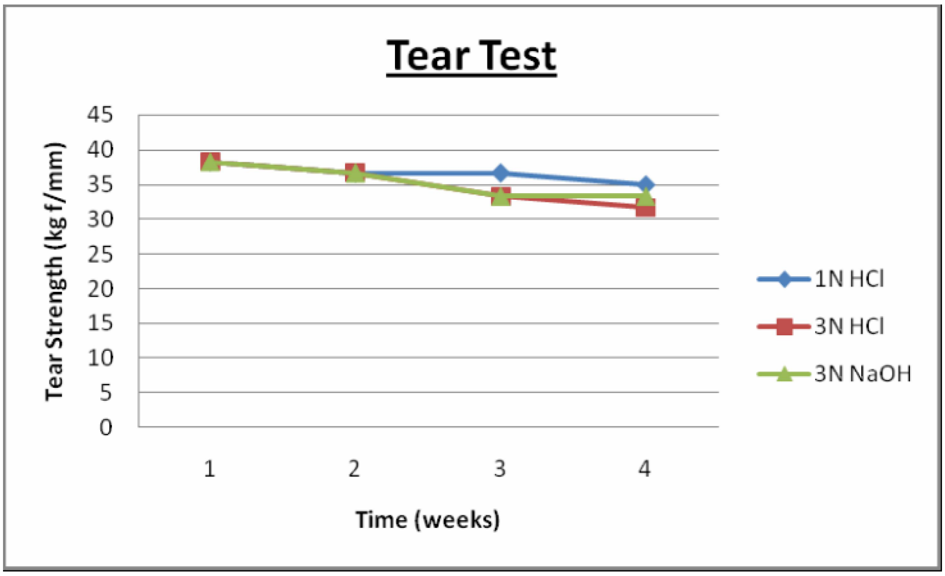
Thickness of Specimen = 0.06 mm



Tear Test

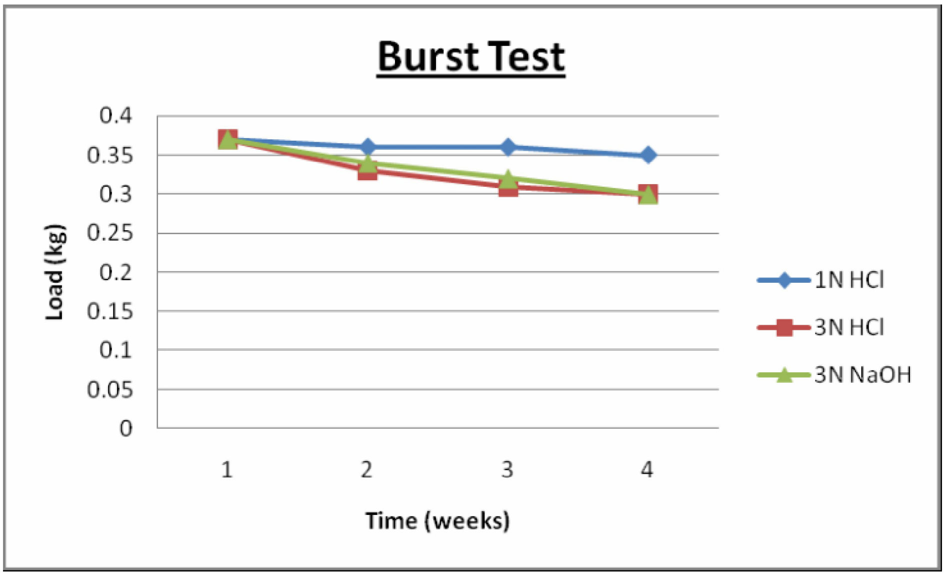
Time Period	1N HCl		3N HCl		3N NaOH	
	Max. Load (kg)	Tear Strength (kg/mm)	Max. Load (kg)	Tear Strength (kg/mm)	Max. Load (kg)	Tear Strength (kg/mm)
0 weeks	2.3	38.3	2.3	38.3	2.3	38.3
1 weeks	2.2	36.7	2.2	36.7	2.2	36.7
2 weeks	2.2	36.7	2.0	33.3	2.0	33.3
3 weeks	2.1	35	1.9	31.7	2.0	33.3

Thickness of Specimen = 0.06 mm



Burst Test

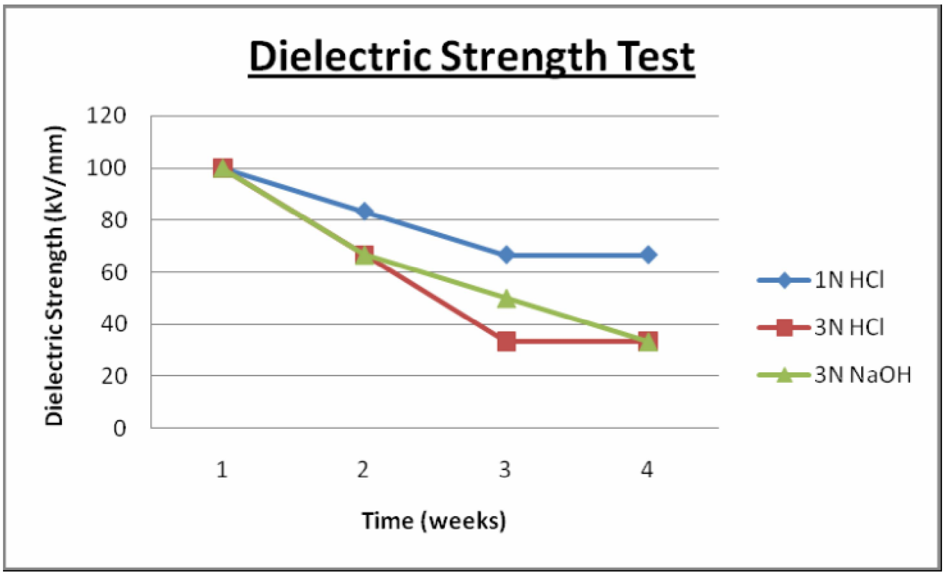
Time Period	1N HCl	3N HCl	3N NaOH
	Load (kg)	Load (kg)	Load (kg)
0 weeks	0.37	0.37	0.37
1 weeks	0.36	0.33	0.34
2 weeks	0.36	0.31	0.32
3 weeks	0.35	0.30	0.30



Dielectric Test

Time Period	1N HCl		3N HCl		3N NaOH	
	Voltage (kV)	D.S.(kV/mm)	Voltage (kV)	D.S.(kV/mm)	Voltage (kV)	D.S.(kV/mm)
0 weeks	6	100	6	100	6	100
1 weeks	5	83.33	4	66.67	4	66.67
2 weeks	4	66.67	2	33.33	3	50
3 weeks	4	66.67	2	33.33	2	33.33

Thickness of Specimen = 0.06 mm



Result

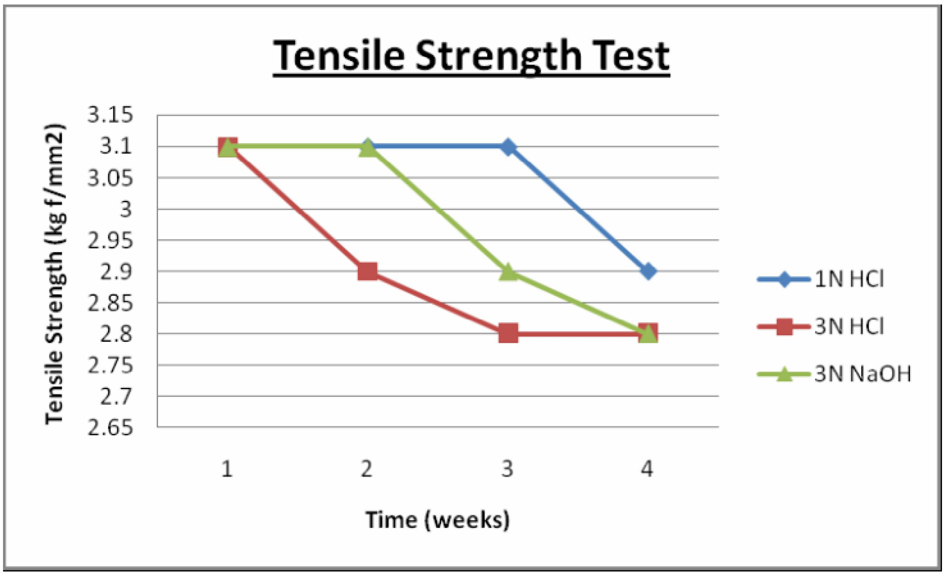
It can be seen that there is degradation in the mechanical and electrical properties of the PE sample used. This deterioration increases with the acidic/basic strength or with the time. The most probable cause for this decrease in properties can be that when the polymer comes in contact with acid or base, the intermolecular and intramolecular bonds tends to break. Due to this breaking of bonds the mechanical strength decreases with time for same acid or it decreases with increasing acidic strength. Moreover there can be one more reason for this degradation, i.e., hydrolysis. Although in general, vinyl polymers are not susceptible to hydrolysis and PE is hydrophobic, so it hydrolyzes rarely.

Sample 3

Tensile Strength Test

Time Period	1N HCl				3N HCl				3N NaOH			
	L (mm)	ΔL (mm)	Wt. (kg)	T.S. (kg f/mm^2)	L (mm)	ΔL (mm)	Wt. (kg)	T.S. (kg f/mm^2)	L (mm)	ΔL (mm)	Wt. (kg)	T.S. (kg f/mm^2)
0 weeks	150	14.2	2.0	3.1	150	14.2	2.0	3.1	150	14.2	2.0	3.1
1 weeks	150	14.0	2.0	3.1	150	13.9	1.9	2.9	150	14.0	2.0	3.1
2 weeks	150	13.9	2.0	3.1	150	13.7	1.8	2.8	150	13.8	1.9	2.9
3 weeks	150	13.8	1.9	2.9	150	13.5	1.8	2.8	150	13.7	1.8	2.8

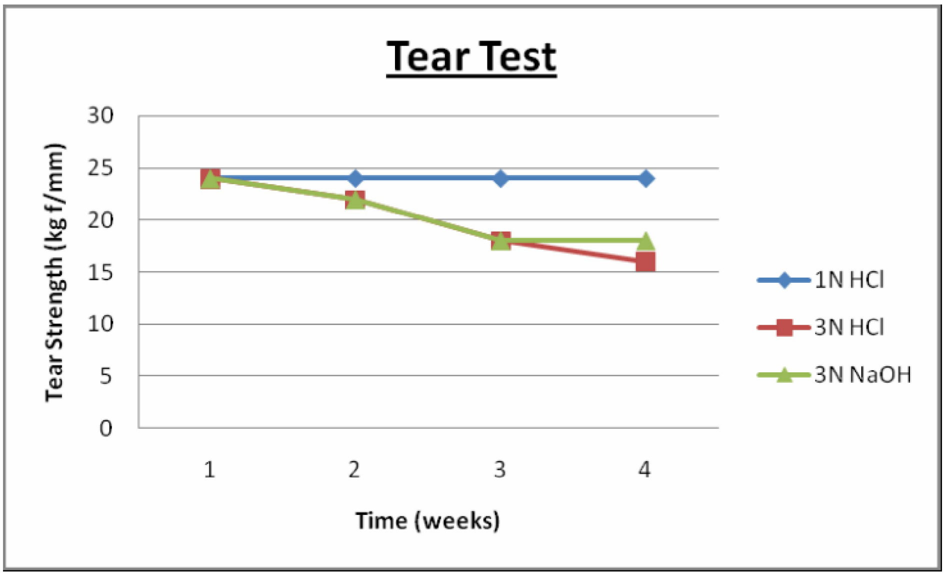
Thickness of Specimen = 0.05 mm



Tear Test

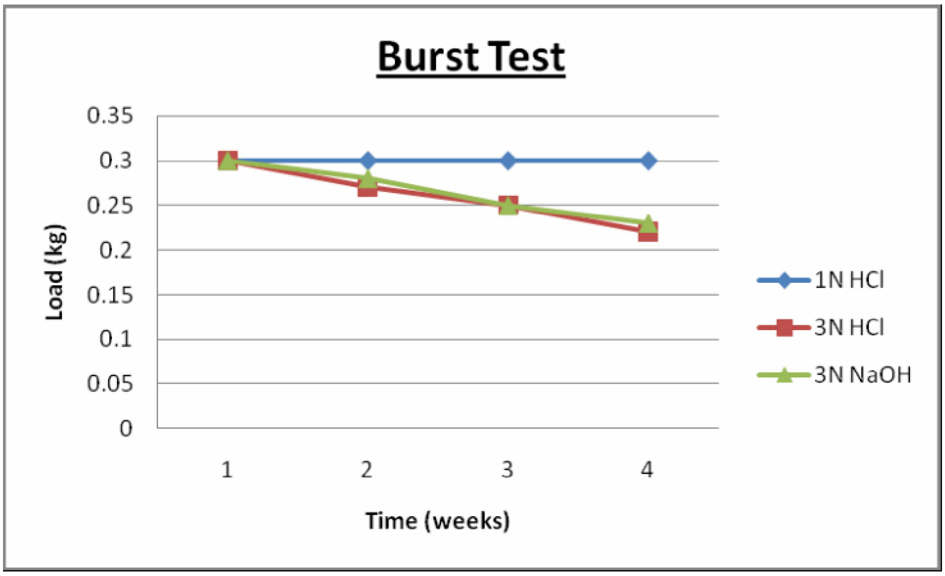
Time Period	1N HCl		3N HCl		3N NaOH	
	Max. Load (kg)	Tear Strength (kg/mm)	Max. Load (kg)	Tear Strength (kg/mm)	Max. Load (kg)	Tear Strength (kg/mm)
0 weeks	1.2	24	1.2	24	1.2	24
1 weeks	1.2	24	1.1	22	1.1	22
2 weeks	1.2	24	0.9	18	0.9	18
3 weeks	1.2	24	0.8	16	0.9	18

Thickness of Specimen = 0.05 mm



Burst Test

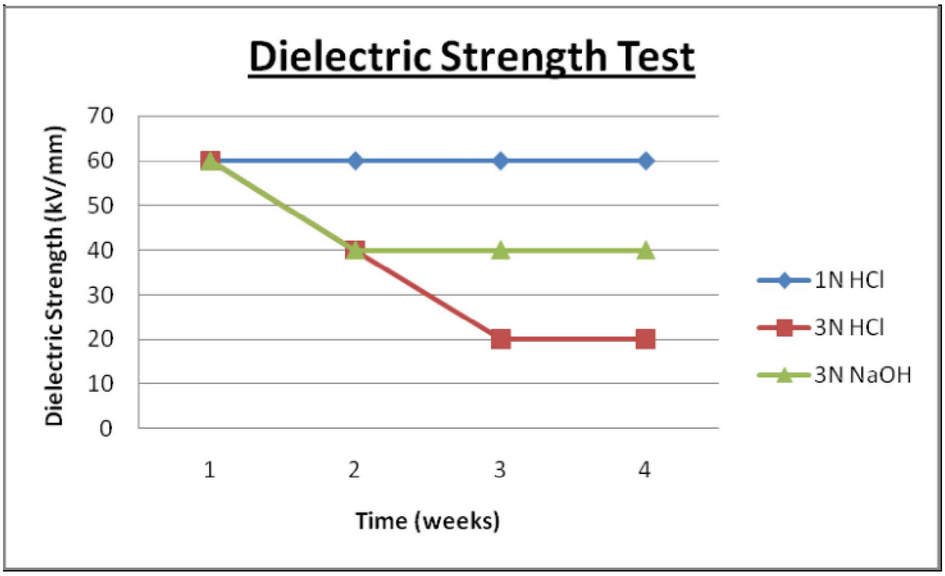
Time Period	1N HCl	3N HCl	3N NaOH
	Load (kg)	Load (kg)	Load (kg)
0 weeks	0.30	0.30	0.30
1 weeks	0.30	0.27	0.28
2 weeks	0.30	0.25	0.25
3 weeks	0.30	0.22	0.23



Dielectric Test

Time Period	1N HCl		3N HCl		3N NaOH	
	Voltage (kV)	D.S.(kV/mm)	Voltage (kV)	D.S.(kV/mm)	Voltage (kV)	D.S.(kV/mm)
0 weeks	3	60	3	60	3	60
1 weeks	3	60	2	40	2	40
2 weeks	3	60	1	20	2	40
3 weeks	3	60	1	20	2	40

Thickness of Specimen = 0.05 mm



Result

It can be seen that there is degradation in the mechanical and electrical properties of the PE sample used. This deterioration increases with the acidic/basic strength or with the time. The most probable cause for this decrease in properties can be that when the polymer comes in contact with acid or base, the intermolecular and intramolecular bonds tends to break. Due to this breaking of bonds the mechanical strength decreases with time for same acid or it decreases with increasing acidic strength. Moreover there can be one more reason for this degradation, i.e., hydrolysis. Although in general, vinyl polymers are not susceptible to hydrolysis.

CONCLUSION

POLYETHYLENE

From the graphical results obtained above, it is clear that the polyethylene film degrades under acidic and basic environment. Its properties show a gradual decrease as the contact time with acid and base increases. So this PE sample is not suitable for long term application under acidic and basic environment. Thus the PE sample needs to be compounded with certain additives to increase its resistance towards acids and bases.

POLYSTYRENE

From the graphical results seen above, it is clear that the polystyrene film degrades under acidic and basic environment. Its properties show a gradual decrease as the contact time with acid and base increases. Although the decrease in properties of PS has shown a more gradual decrease as compared to PE. So this PS sample is also not suitable for long term application under acidic and basic environment. Hence the PE sample needs to be compounded with certain additives to increase its resistance towards acids and bases.

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