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To Optimize the Parameters for Waterproof Breathable Coatings on Textile

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ABSTRACT –
Based on fundamental principles and design of waterproof breathability fabrics, it can be categorized as, closely woven fabrics, micro porous membranes and coating, hydrophilic membranes and coating, combination of micro porous and hydrophilic membranes and coating. In this, we obtained waterproof breathable cotton fabric by applying fluorocarbon, silicone and combination of silicone and fluorocarbon at different concentration, with two catalyst magnesium chloride & di-ammonium phosphate at various concentration, temperature and time.

Keywords: waterproof, water repellent and water breathable.

INTRODUCTION

Coated fabric is 'material composed of two or more layers, at least one of which is a textile fabric and at least one of which is a substantially continuous polymeric layer. The layers are bonded closely together by means of an added adhesive or by the adhesive properties of one or more of the component layers'. The second definition is, 'A textile fabric on which there has been formed in situ, on one or both surfaces, a layer or layers of adherent coating material'.

Textile Terms and Definitions defines a 'laminated fabric' (or a 'combined fabric') as, 'a material composed of two or more layers, at least one of which is a textile fabric, bonded closely together by means of an added adhesive, or by the adhesive properties of one or more of the component layers'.[1]

BREATHABLE TEXTILE

Breathability of fabric is the ability of clothing to allow the transmission of moisture vapour by diffusion and therefore facilitate evaporative cooling. Comfort is associated with the ability of the body to maintain a constant core temperature not only under different environmental conditions but also at different work rates for the body. During rest, most surplus body heat is lost by conduction and radiation, whereas during physical activity, the dominant means of losing excess body heat is by evaporation of perspiration.[2]

Water repellent fabrics are those which resist being wetted by water, water drops will roll off the fabric. A fabric's resistance to water will depend on the nature of the fibre surface, the porosity of the fabric and the dynamic force behind the impacting water spray. It is important to distinguish between water-repellent and water-proof fabrics. Waterproof fabric completely prevents the penetration and absorption of liquid water. The term breathable implies that the fabric is actively ventilated. These are resistant to the penetration of water under much higher hydrostatic pressure than are water-repellent fabrics. [3, 4]

Sankhe M. D. et al attempted to produce UV resistance breathable fabric for cold region, Perfluoro-alkyl type fluorocarbon based compound and fluorocarbon resin type compound were used as water repellent finishes and best result obtained by fluorocarbon resin type compound for water repellence. Breaking strength, elongation,

tearing strength, water vapour permeability, water repellence and air permeability were tested for performance of coating. From these, concluded that fluorocarbon resin type compound with 30 gpl is effective for breathability and air permeability.[5]

Daniel J. Gohlke and Joseph C. Tanner, during and after World War II have developed laboratory tests to quantify water proof ness and vapour permeability. They have also determined minimum values of these properties that are required to keep the wearer both dry and comfortable. There have been several commercial developments in this area that initially appeared to fulfil the waterproof/comfort requirements. Gore-Tex is microspores polymeric film of polytetrafluoroethylene used for outer wear material, which permits use of number of additives for bonding. It is used to provide a water proof material which moisture vapour permeability sufficient to allow evaporative cooling. Comfort is check by moisture vapour transmission rate.[6]

Phil Gibsonapplied paraffin wax emulsion of different concentration on 50/50 PC used using stearic acid triethanolamine and aluminium chloride, which is best deactivating agent of hydrophobicity. Water repellence optimum at paraffin wax 10.5%, stearic acid 4.5%, TEA 2.5%. These gives water repellence up to 80 and increase stiffness by treating with deactivated emulsion, also in presence of fluorinated finish (NAVA FB) increases water repellence up to 100. In this mentioned that the water repellence can be formed by hydrocarbon hydrophobes, silicones and fluorochemicals.[7]

Johann Muller studied to achieve required silicones rubber with highly specialized characteristics profile. For electrical protection from heat and weather for this silicones coating are used. Bellow expansion joints, used in industry for flexible connection of gas exchange hear several layer of glass fiber care coated with silicone. Transfer and process conveyer belts which causes without solvent. Silicone resin emulsion used for strengthen and stiffing. [8]

Fukazawa T et al derived new apparatus for measurement of water vapour permeable resistance of textile with and without temperature different on both side of fabric. Temperature effect on water vapour resist is small then pressure, as increase in condensation of specimen causes increases simulated altitude and decrease in water vapour resistance, this shows decrease water vapour resistance enhance condensation in cloths and thus may cause further discomfort and drop in body temperature at high attitudes.[9]

Wood coke A. H. found new clothing parameter, moisture permeability index which describe efficiency of fabric in transferring moisture and its latent heat. It includes heat loss from sweat evaporation apart from existing dry or non-sweating heat loss to clothing insulation and temperature.[10]

Material & Methods

Materials:

100 % cotton Fabric of 140 GSM.
Chemical Used:
Fluorocarbon: Resiguard (SR), Resiguard (OWR).
Silicone: Aqurest WR1000, Micro Amino Silicon.
Catalyst: Magnesium Chloride & Di-ammonium phosphate

Methods:

Firstly cotton fabric desize, mercerized, scoured & bleached. Fluorocarbon at five different concentration applied by pad dry two dip two nip method and cured at different temperature & time. The pressure of padding mangle was maintained in range of 0.5 to 1 kg/cm^2.

Table no. 1 Number of samples with varying concentration, temp & time.

Sr. no	Chemical conc (gpl)	Catalyst (%)	Time (min)	Temp (^{O}C)
1	30	0.25	1	120
2	30	0.5	3	140
3	30	0.75	5	160
4	30	1	7.5	180
5	30	1.5	10	200
6	40	0.25	1	120
7	40	0.5	3	140
8	40	0.75	5	160
9	40	1	7.5	180
10	40	1.5	10	200
11	50	0.25	1	120
12	50	0.5	3	140
13	50	0.75	5	160
14	50	1	7.5	180
15	50	1.5	10	200
16	60	0.25	1	120
17	60	0.5	3	140
18	60	0.75	5	160
19	60	1	7.5	180
20	60	1.5	10	200
21	70	0.25	1	120
22	70	0.5	3	140
23	70	0.75	5	160
24	70	1	7.5	180
25	70	1.5	10	200

Test Methods
Air permeability ASTM D 737-04
Spray RatingIS 390-1975
Hydrostatic tester
Water vapour transmissionASTEM E 96-66

Result & Discussion

Table 2: Effect of Physical Parameters at Various Concentration, Time & Temperature by using Resiguard SR

Sr. no	Chemical Conc. (gpl)	Catalyst (%)	Time (min)	Temp (^{O}C)	Spray Rating		Water Breathability (mm)		Water Vapor Transmission (gms/cm^2/24hrs)		Air permeability (cm^3/cm^2/sec)	
					$MgCl_2$	DAP	$MgCl_2$	DAP	$MgCl_2$	DAP	$MgCl_2$	DAP
1	30	0.25	1	120	72	53.33	221	209	722.4	705.6	4.6	4.7
2	30	0.5	3	140	75	41.67	233	217	710.6	702.3	4.55	4.7
3	30	0.75	5	160	78	58.57	230	221	698.2	699.1	4.4	4.65
4	30	1	7.5	180	80	60	238	221	690.7	698.4	4.6	4.4
5	30	1.5	10	200	86	67.14	242	238	701.2	697.2	4.3	4.3
6	40	0.25	1	120	72	50	226	214	718.6	684.2	4.4	4.6
7	40	0.5	3	140	80	54	230	219	704.4	684	4.35	4.56
8	40	0.75	5	160	80	58.57	233	225	691.2	674.1	4.35	4.5
9	40	1	7.5	180	80	63.33	240	230	689.1	673.7	4.25	4.3
10	40	1.5	10	200	84	78.33	248	246	687.2	672.1	4.2	4.45
11	50	0.25	1	120	70	40	232	220	712.5	680.4	4.2	4.4
12	50	0.5	3	140	80	66	239	226	702.3	674.5	4.15	4.35

13	50	0.75	5	160	80	76	245	234	684.4	668.1	4.05	4.3
14	50	1	7.5	180	86	78	248	242	676.7	659.7	3.95	4.2
15	50	1.5	10	200	88	78	251	250	670.6	658.4	3.9	4.1
16	60	0.25	1	120	80	66.67	235	228	689.8	676.1	3.8	4.2
17	60	0.5	3	140	80	70	246	235	683.5	668.1	3.75	4.15
18	60	0.75	5	160	80	66.67	252	250	678.2	654.1	3.67	4
19	60	1	7.5	180	88	70	258	256	661.7	650.9	3.6	3.95
20	60	1.5	10	200	86.67	80	260	256	665.2	647.3	3.5	3.9
21	70	0.25	1	120	80	50	238	235	670.4	630.4	3.7	3.9
22	70	0.5	3	140	83.33	54	251	234	668.2	621.1	3.5	3.85
23	70	0.75	5	160	88.57	56	254	246	652.7	614.8	3.47	3.7
24	70	1	7.5	180	88.33	60	275	246	640.1	594.2	3.28	3.5
25	70	1.5	10	200	90	64	278	268	638.4	576.5	3.2	3.4

The result of Table no. 2 indicates the values of spray rating, water breathability, water vapour transmission and air permeability. Resiguard SR at 30gpl concentration, 1.5% of Magnesium chloride as a catalyst at 10 minutes curing & temperature at 200 ^{0}c, indicates 86 as spray rating and 242mm as water breathability, 701.2 gms/cm^2/sec as water vapour transmission and 4.3 cm^3/cm^2/sec as air permeability. Whereas at 70 gpl concentration shows 90 as spray rating, 278 mm water breathability, 638.4 gms/cm^2/sec as water vapour transmission and 3.2 cm^3/cm^2/sec as air permeability. This indicates that as concentration of Resiguard SR increases with increase in catalyst concentration, time & temperature of curing the spray rating increases, water breathability also increases (comfort increases), water vapour transmission decreases and air permeability reduces. This may be attributed to the fact that a coating of Resiguard SR increases, and hence water repellency property of fabric increases (as shown by the value of spray rating and water breathability), at the same time water vapour transmission and air permeability decreases and this may be due to heavy decomposition of crosslinked Resiguard SR which blocks the pores of interstice of warp and weft and hence water vapour and air is not permitted to pass through the fabric.

From the result and discussion, it may be better to use Resiguard SR 50 gpl concentration with 1 % of Magnesium chlorideas catalyst, 7.5 minutes and 180 ^{0}c gives optimum result.

Amongst Magnesium chloride and Di-ammonium phosphate, the result of both these catalyst indicates that Magnesium chloride gives far better results of water repellence property and less water vapour and air permeability & this may be because of higher acidic pH of Magnesium chloride at high temperature and hence

better curing with good film cross linking than lower acidic pH of Di-ammonium phosphate which gives slightly inferior cross linking at the same conditions.

Table 3: Effect of Physical Parameters at Various Concentration, Time & Temperature by using RESIGUARD OWR Table 3: Effect of Physical Parameters at Various Concentration, Time & Temperature by using RESIGUARD OWR

SR. no	Chemical Conc. (gpl)	Catalyst (%)	Time (min)	Temp (^{O}C)	Spray Rating		Water Breathability (mm)		Water Vapor Transmission (gms/cm^2/24hrs)		Air permeability (cm^3/cm^2/sec)	
					$MgCl_2$	DAP	$MgCl_2$	DAP	$MgCl_2$	DAP	$MgCl_2$	DAP
1	30	0.25	1	120	75	71	287	248	718.1	619.24	7.5	6.9
2	30	0.5	3	140	77	74.5	292	252	715.49	617.37	7.42	6.81
3	30	0.75	5	160	79	75.8	298	258	713.57	614.36	7.4	6.79
4	30	1	7.5	180	78	76.1	301	261	710.46	612.87	7.34	6.7
5	30	1.5	10	200	78	80	304	264	694.1	611.2	7.2	6.65
6	40	0.25	1	120	76.66	72	298	268	680.12	610.1	7.12	6.6
7	40	0.5	3	140	77	74	305	271	684.15	610.1	6.94	6.59
8	40	0.75	5	160	78.87	75	310	276	682.6	610.2	6.8	6.5
9	40	1	7.5	180	79	77.5	312	284	681.5	609.74	6.72	6.52
10	40	1.5	10	200	79	80	315	291	680.19	608.57	6.7	6.45
11	50	0.25	1	120	78.56	76	317	308	670.24	600.2	6.8	6.4
12	50	0.5	3	140	79.88	78.2	318	312	668.43	597.42	6.74	6.5
13	50	0.75	5	160	80	80	319	315	662.34	592.61	6.72	6.59
14	50	1	7.5	180	80	80	320	318	660.98	590.2	6.68	6.6
15	50	1.5	10	200	80	61.67	322	320	654.28	586.24	6.6	6.63
16	60	0.25	1	120	82	64.5	327	327	650.12	580.74	6.54	6.6
17	60	0.5	3	140	84	66	330	334	642.73	576.32	6.5	6.51
18	60	0.75	5	160	84	70	334	338	637.8	570.47	6.47	6.42

19	60	1	7.5	180	85	75	357	342	635.12	562.97	6.38	6.4
20	60	1.5	10	200	88	80	338	348	630.45	567.2	6.31	6.36
21	70	0.25	1	120	90	80	341	352	627.12	560.45	6.29	6.27
22	70	0.5	3	140	90	80	350	359	626.89	557.26	6.28	6.18
23	70	0.75	5	160	90	85	354	362	623.4	549.8	6.25	5.81
24	70	1	7.5	180	90	88	360	363	622.7	548.57	6.2	5.64
25	70	1.5	10	200	90	88	378	364	620.24	541.42	6.18	5.5

The result of Table no. 3 indicates the values of spray rating, water breathability, water vapour transmission and air permeability. Resiguard OWR at 30 gpl concentration, 1.5% of Magnesium chloride as a catalyst at 10 minutes curing & temperature at 200 ^{0}c, indicates 78 as spray rating and 304 mm as water breathability, 694.1 gms/cm^2/sec as water vapour transmission and 7.2 cm^3/cm^2/sec as air permeability. Whereas at 70 gpl concentration shows 90 as spray rating, 378 mm water breathability, 620.24 gms/cm^2/sec as water vapour transmission and 6.18 cm^3/cm^2/sec as air permeability. This indicates that as concentration of Resiguard OWR increases with increase in catalyst concentration, time & temperature of curing the spray rating increases, water breathability also increases (comfort increases), water vapour transmission decreases and air permeability reduces. This may be attributed to the fact that a coating of Resiguard OWR increases, and hence water repellency property of fabric increases (as shown by the value of spray rating and water breathability), at the same time water vapour transmission and air permeability decreases and this may be due to heavy decomposition of crosslinked Resiguard OWR which blocks the pores of interstice of warp and weft and hence water vapour and air is not permitted to pass through the fabric.

From the result and discussion, it may be better to use Resiguard OWR 60 gpl concentration with 1.5 % of magnesium chloride as catalyst, 10 minutes and 200^{0}c gives optimum result.

Amongst Magnesium chloride and Di-ammonium phosphate, the result of both these catalyst indicates that Magnesium chloride gives far better results of water repellency property and less water vapour and air permeability & this may be because of higher acidic pH of Magnesium chloride at high temperature and hence better curing with good film coating than lower acidic pH of Di-ammonium phosphate which gives slightly inferior crosslinking at the same conditions.

Table 4: Effect of Physical Parameters at Various Concentration, Time & Temperature by using AQUREST WR1000

Sr. no	**Chemical conc (gpl)**	**Catalyst (%)**	**Time (min)**	**Temp (^{O}C)**	**Spray Rating**		**Water Breathability (mm)**		**Water Vapor Transmission (gms/cm^2/24hrs)**		**Air Permeability (cm^3/cm^2/sec)**	
					$MgCl_2$	**DAP**	**$MgCl_2$**	**DAP**	**$MgCl_2$**	**DAP**	**$MgCl_2$**	**DAP**
1	30	0.25	1	120	50	52	200	250	644.22	674.28	6.3	6.72
2	30	0.5	3	140	55.42	53	207	254	640.12	670.22	6.12	6.55

3	30	0.75	5	160	55	54.78	214	260	638.76	667.81	5.9	6.52
4	30	1	7.5	180	57	55	219	262	633.2	663.49	5.86	6.49
5	30	1.5	10	200	58.68	55.8	225	267	630.81	659.37	5.83	6.45
6	40	0.25	1	120	60	58	227	273	624.72	657.12	5.82	6.41
7	40	0.5	3	140	64	60	230	277	620.08	654.1	5.8	6.38
8	40	0.75	5	160	65	60	232	284	615.24	650.72	5.79	6.34
9	40	1	7.5	180	65.78	62	236	289	612.68	648.62	5.78	6.29
10	40	1.5	10	200	66	65	242	295	608.36	644.21	5.77	6.21
11	50	0.25	1	120	66	67	250	307	604.54	641.24	5.74	6.05
12	50	0.5	3	140	68	69	254	311	600.24	640.25	5.75	5.8
13	50	0.75	5	160	70	70.2	258	318	599.01	638.23	5.76	5.67
14	50	1	7.5	180	72	72	260	324	596.26	636.12	5.75	5.61
15	50	1.5	10	200	72	75	263	327	592.14	634.21	5.74	5.58
16	60	0.25	1	120	73.41	76.5	266	330	590.24	631.22	5.73	5.51
17	60	0.5	3	140	74	77	268	334	589.97	628.3	5.72	5.48
18	60	0.75	5	160	74.89	78	271	337	587.14	625.41	5.71	5.42
19	60	1	7.5	180	75	79	273	342	585.21	622.42	5.7	5.4
20	60	1.5	10	200	77.2	80	274	347	583.24	620.78	5.69	5.37
21	70	0.25	1	120	70	80	275	353	580.25	618.12	5.69	5.38
22	70	0.5	3	140	72	80	276	356	576.71	615.22	5.68	5.32
23	70	0.75	5	160	74	80	279	359	575.22	610.25	5.68	5.2
24	70	1	7.5	180	74.54	80	280	365	574.12	608.21	5.67	5.01
25	70	1.5	10	200	78	82	282	372	571.89	604.71	5.67	4.93

The result of Table no. 4 indicates the values of spray rating, water breathability, water vapour transmission and air permeability. Aqurest WR1000 at 30 gpl concentration, 1.5% of Di-ammonium phosphate as a catalyst at 10 minutes curing & temperature at 200 ^{0}c, indicates 55.8 as spray rating and 267 mm as water breathability, 659.37 gms/cm^2/sec as water vapour transmission and 6.54 cm^3/cm^2/sec as air permeability. Whereas at 70 gpl concentration shows 82 as spray rating, 372 mm water breathability, 604.71 gms/cm^2/sec as water vapour transmission and 4.93 cm^3/cm^2/sec as air permeability. This indicates that as concentration of Aqurest WR1000

increases with increase in catalyst concentration, time & temperature of curing the spray rating increases, water breathability also increases (comfort increases), water vapour transmission decreases and air permeability reduces. This may be attributed to the fact that a coating of Aqurest WR1000 increases, and hence water repellency property of fabric increases (as shown by the value of spray rating and water breathability), at the same time water vapour transmission and air permeability decreases and this may be due to heavy decomposition of cross linked Aqurest WR1000 which blocks the pores of interstice of warp and weft and hence water vapour and air is not permitted to pass through the fabric.

From the result and discussion, it may be better to use Aqurest WR100060 gpl concentration with 1.5 % of Di-ammonium phosphate as catalyst, 10 minutes and 200^0c gives optimum result.

Amongst Magnesium chloride and Di-ammonium phosphate, the result of both these catalyst indicates that Di-ammonium phosphate gives far better results of water repellence property and less water vapour and air permeability& this may be because of lower acidic pH of Di-ammonium phosphate at high temperature and hence better curing with good film cross linked than higher acidic pH of Magnesium chloride which gives slightly inferior coating at the same conditions.

Table 5: Effect of Physical Parameters at Various Concentration, Time & Temperature by using Micro Amino Silicone

Sr. no	Chemical Conc. (gpl)	Catalyst (%)	Time (min)	Temp (^OC)	Spray Rating		Water Breathability (mm)		Water Vapor Transmission (gms/cm^2/24hrs)		Air permeability (cm^3/cm^2/sec)	
					$MgCl_2$	DAP	$MgCl_2$	DAP	$MgCl_2$	DAP	$MgCl_2$	DAP
1	30	0.25	1	120	0	50	90	91	614.85	659.34	7.42	7.93
2	30	0.5	3	140	45	50	90	92	607.16	655.87	7.38	7.9
3	30	0.75	5	160	46	50	90	92	605.28	654.39	7.37	7.89
4	30	1	7.5	180	48	50	91	92	601.05	652.82	7.33	7.86
5	30	1.5	10	200	50	50	92	93	599.12	650.89	7.3	7.82
6	40	0.25	1	120	50	50	92	93	597.21	647.28	7.23	7.77
7	40	0.5	3	140	50	50	92	93	593.69	643.15	7.21	7.76
8	40	0.75	5	160	50	50	93	94	591.25	640.98	7.19	7.74
9	40	1	7.5	180	50	50	94	94	589.36	638.34	7.16	7.71
10	40	1.5	10	200	50	50	94	95	587.17	634.22	7.03	7.68
11	50	0.25	1	120	50	50	94	96	585.24	632.54	6.78	7.64

12	50	0.5	3	140	50	50	94	96	583.13	630.19	6.75	7.61
13	50	0.75	5	160	50	50	95	96	580.22	628.37	6.72	7.58
14	50	1	7.5	180	50	50	95	97	578.91	625.13	6.69	7.56
15	50	1.5	10	200	50	50	95	98	575.87	622.09	6.64	7.54
16	60	0.25	1	120	50	50	95	98	573.28	619.87	6.52	7.51
17	60	0.5	3	140	50	50	96	98	570.12	614.89	6.49	7.49
18	60	0.75	5	160	50	50	96	98	568.38	611.04	6.43	7.46
19	60	1	7.5	180	50	50	96	99	565.97	608.68	6.38	7.42
20	60	1.5	10	200	50	50	96	99	563.87	603.05	6.31	7.39
21	70	0.25	1	120	50	50	97	100	560.21	598.23	6.27	7.35
22	70	0.5	3	140	50	50	97	100	558.48	596.87	6.24	7.31
23	70	0.75	5	160	50	50	97	100	554.28	592.24	6.19	7.28
24	70	1	7.5	180	50	50	98	100	552.14	589.21	6.12	7.23
25	70	1.5	10	200	50	50	98	100	550.74	587.56	6.02	7.22

The result of Table no. 5 indicates the values of spray rating, water breathability, water vapour transmission and air permeability. Micro Amino Silicone at 30 gpl concentration, 1.5% of Di-ammonium phosphate as a catalyst at 10 minutes curing & temperature at 200 ^{0}c, indicates 50 as spray rating and 93 mm as water breathability, 650.89 gms/cm^2/sec as water vapour transmission and 7.82 cm^3/cm^2/sec as air permeability. Whereas at 70 gpl concentration shows 50 as spray rating, 100 mm water breathability, 587.56 gms/cm^2/sec as water vapour transmission and 7.22 cm^3/cm^2/sec as air permeability. This indicates that as concentration of Micro Amino Silicone increases with increase in catalyst concentration, time & temperature of curing the spray rating increases, water breathability also increases (comfort increases), water vapour transmission decreases and air permeability reduces. This may be attributed to the fact that a coating of Micro Amino Silicone increases, and hence water repellence property of fabric increases (as shown by the value of spray rating and water breathability), at the same time water vapour transmission and air permeability decreases and this may be due to heavy decomposition of cross linked Micro Amino Silicone which blocks the pores of interstice of warp and weft and hence water vapour and air is not permitted to pass through the fabric.

From the result and discussion, it may be better to use Micro Amino Silicone 60 gpl concentration with 1 % of Di-ammonium phosphate as catalyst, 7.5 minutes and 180 ^{0}c gives optimum result.

Amongst Magnesium Chloride and Di-ammonium phosphate, the result of both these catalyst indicates that Di-ammonium phosphate gives far better results of water repellence property and less water vapour and air permeability & this may be because of lower acidic pH of Di-ammonium phosphate at high temperature and

hence better curing with good film cross linking than higher acidic pH of Magnesium chloride which gives slightly inferior coating at the same conditions.

Table no.6: Effect of physical parameters by varying catalyst by combinations of fluorocarbon &silicone (50: 50)

Sr. no	Chemical conc (50 + 50 gpl)	Catalyst (%)	Time (min)	Temp (^{O}C)	Spray Rating		Water Breathability (mm)		Water Vapor Transmission (gms/cm^2/24hrs)		Air permeability (cm^3/cm^2/sec)	
					$MgCl_2$	DAP	$MgCl_2$	DAP	$MgCl_2$	DAP	$MgCl_2$	DAP
1	Resiguard SR + Aqurest WR1000	1.5	7.5	180	87	75	362	338	652.21	635.89	6.01	5.82
2	Resiguard SR + Micro Amino Silicone	1.5	7.5	180	82	80	323	312	672.21	652.41	6.2	6.08
3	Resiguard OWR + Aqurest WR1000	1.5	7.5	180	94	91	375	364	584.37	604.35	5.87	5.62
4	Resiguard OWR + Micro Amino Silicone	1.5	7.5	180	85	82	340	326	640.37	624.79	6.9	6.43

The result of Table no. 6 indicates the values of spray rating, water breathability, water vapour transmission and air permeability. Combination of Resiguard SR and Aqurest WR1000of 50:50 gpl with 1.5% magnesium chloride as catalyst and time 7.5 minute at 180 ^{0}C, indicates 87 spray rating, 362 mm water breathability, 652.21gms/cm^2/24hrs of water vapour transmission and air permeability of 6.01 cm^3/cm^2/sec. Combination of Resiguard SR and Micro Amino Silicone of 50:50 gpl with 1.5% magnesium chloride as catalyst and time 7.5 minute at 180 ^{0}C, indicates 82 spray rating, 323 mm water breathability, 672.21 gms/cm^2/24hrs of water vapour transmission and air permeability of 6.2 cm^3/cm^2/sec. Combination of Resiguard OWR and Aqurest WR1000 of 50:50 gpl with 1.5% magnesium chloride as catalyst and time 7.5 minute at 180 ^{0}C, indicates 91 spray rating, 375 mm water breathability, 584 gms/cm^2/24hrs of water vapour transmission and air permeability of 5.87 cm^3/cm^2/sec. Combination of Resiguard OWR and Micro Amino Silicone 50:50 gpl with 1.5% magnesium chloride as catalyst and time 7.5 minute at 180 ^{0}C, indicates 85 spray rating, 340 mm water breathability, 640.35 gms/cm^2/24hrs of water vapour transmission and air permeability of 6.9 cm^3/cm^2/sec.

Amongst of all, the combination of fluorocarbon and silicone shows good result comparison with single chemical when used alone. The combination of fluorocarbon Resiguard OWR and Silicone Aqurest WR1000 at 1.5 % of magnesium chloride and 7.5 minute at 180 ^{0}C givesthe best result of spray rating, water breathability, water vapour transmission and air permeability.

CONCLUSION

From the result and discussion it may be concluded that for getting waterproof breathable coatings fluorocarbon Resiguard OWR gives better result as compare to other chemical like Resiguard SR, Aqurest WR1000 & Micro Amino Silicone. The combination of Resiguard OWR with Quest WR1000 (50:50 proportion) gives good result when compared with Resiguard OWR alone.

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