GreenCentre Canada

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GoNano

October 26, 2023

PROJECT OBJECTIVES

- The first objective is to prepare three formulations of an asphalt shingle coating mixture and analyze shingles coated with these mixtures. The coated shingles will be analyzed by FTIR spectroscopy and an impact test (non-ASTM).

- The second objective, informed by the initial tests, is to examine the preparation of up to three new formulations and analyze shingles coated with these mixtures.

ASPHALT SHINGLE COATING FORMULATIONS

- Six coating formulations were prepared:
    1. 100% SoyBean Oil.
    2. Revive Concentration Variation
    3. GoNano Revive
    4. Shingle Saver Concentration Variation
    5. GoNano Shingle Saver
    6. Futur product (not disclose)

IMPACT TEST

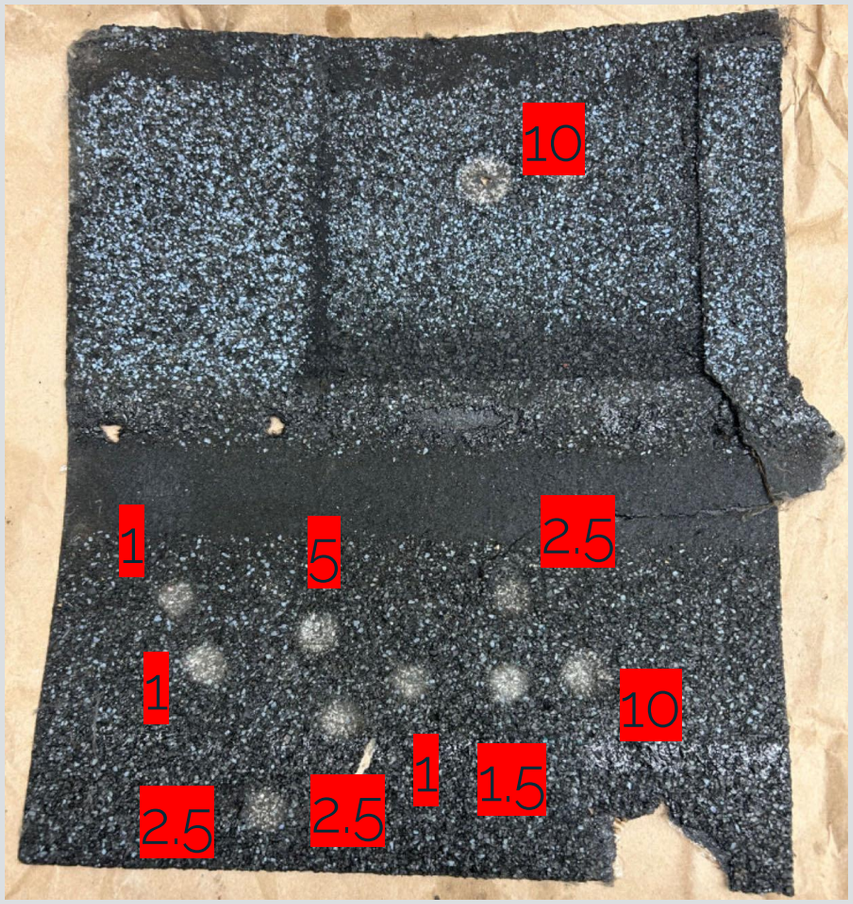
- A 3 inches ball (hard wear-resistant 52100 alloy steel balls – 1.8 Kg) is dropped from a 10 feet long PVC pipe and let it to reach a shingle (which is placed on top of a piece of wood laying on the floor).
- A picture of the shingles before and after each impact is taken.
- The ball is dropped in the shingle 3 times, in different areas.
- 24 samples were tested, in total (4 shingles, 6 formulations each + control)

Picture: PVC pipe held in the ladder, keeping it about 0.5 foot distance from the floor.

IMPACT TEST

- The energy of the ball when it hit the surface is calculated with the following equation: $E = \frac{1}{2} mv^2 = mgh$, where m is the mass in kilograms, g is the acceleration due to gravity (9.8 m/s^2 at the surface of the earth) and h is the height in meters. The ball mass is 1.8 kg.

Height	Energy
3.048 m (10 ft)	53.8 J
1.524 m (5 ft)	26.9 J
0.762 (2.5 ft)	13.5 J
0.457 m (1.5 ft)	8.1 J
0.305 m (1 ft)	5.4 J



Blue shingle-Formulation 1

Kinetic energies

produced by ASTM, FM, and UL standard test methods.

Standard	Diameter	Mass	Distance	Energy
ASTM D 3746	2” (50 mm)	2.27 lbs (kg)	4'5.0” (1355 mm)	30.0 J
FM Class I-SH	1.75” (45 mm)	0.360 lbs (kg)	17'9.5” (5400 mm)	19.0 J
FM Class I-MH	2” (51 mm)	0.737 lbs (kg)	5’ (1500 mm)	10.8 J
UL Class 1	1.25” (32 mm)	0.28 lbs (0.127 kg)	12’ (3700 mm)	4.6 J
UL Class 2	1.5” (38 mm)	0.48 lbs (0.218 kg)	15’ (4600 mm)	9.8 J
UL Class 3	1.75” (46 mm)	0.79 lbs (0.358 kg)	17’ (5200 mm)	18.3 J
UL Class 4	2” (51 mm)	1.15 lbs (0.521 kg)	20’ (6100 mm)	31.2 J
GoNano Test	**3” (76 mm)**	**3.9 lbs (1.8 Kg)**	**10’ (3050 mm)**	**53.8 J**

Terminal Velocities and Energies of Hailstones

Diameter	Terminal Velocity	Approximate Impact Energy
1 in (2.5 cm)	73 ft/s, 50 mi/hr (22.3 m/s)	<1 ft·lbs (<1.36 Joules)
1-1/4 in (3.2 cm)	82 ft/s, 56 mi/hr (25.0 m/s)	4 ft·lbs (5.42 Joules)
1-1/2 in (3.8 cm)	90 ft/s, 61 mi/hr (27.4 m/s)	8 ft·lbs (10.85 Joules)
1-3/4 in (4.5 cm)	97 ft/s, 66 mi/hr (29.6 m/s)	14 ft·lbs (18.96 Joules)
2 in (5.1 cm)	105 ft/s, 72 mi/hr (32.0 m/s)	22 ft·lbs (29.80 Joules)
2-1/2 in (6.4 cm)	117 ft/s, 80 mi/hr (35.7 m/s)	53 ft·lbs (71.9 Joules)
2-3/4 in (7.0 cm)	124 ft/s, 85 mi/hr (37.8 m/s)	81 ft·lbs (109.8 Joules)
3 in (7.6 cm)	130 ft/s, 88 mi/hr (39.6 m/s)	120 ft·lbs (162.7 Joules)

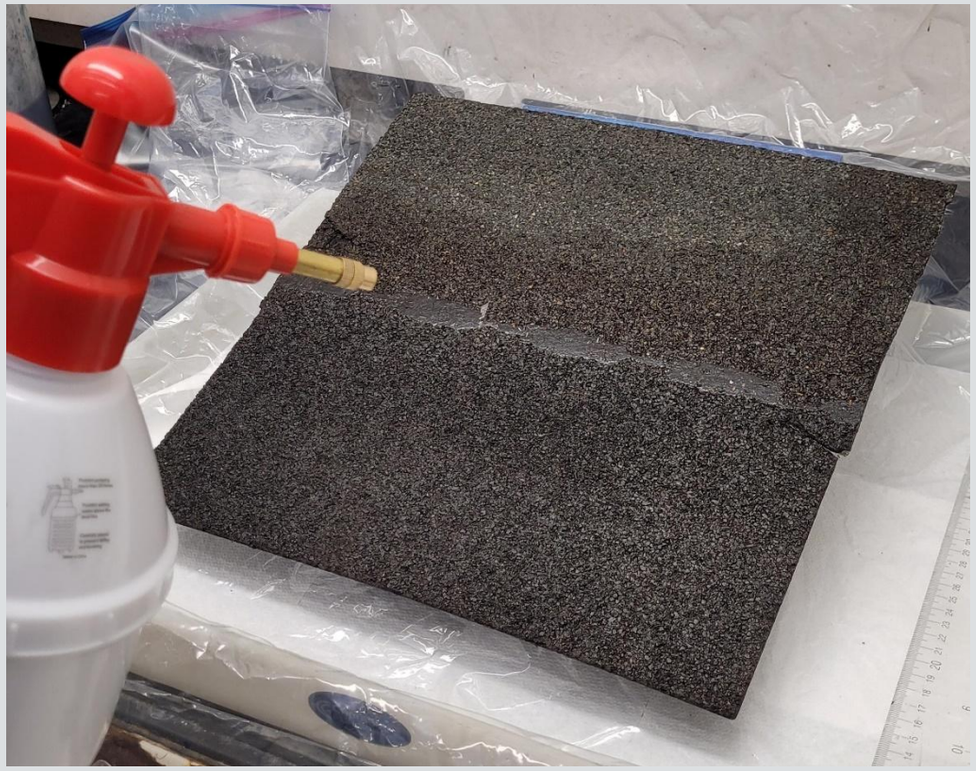
*These values are derived from the impact energy of hailstones graphed by J.A.P. Laurie in 1960

APPLYING FORMULATIONS TO SHINGLES

- Four shingles were tested:

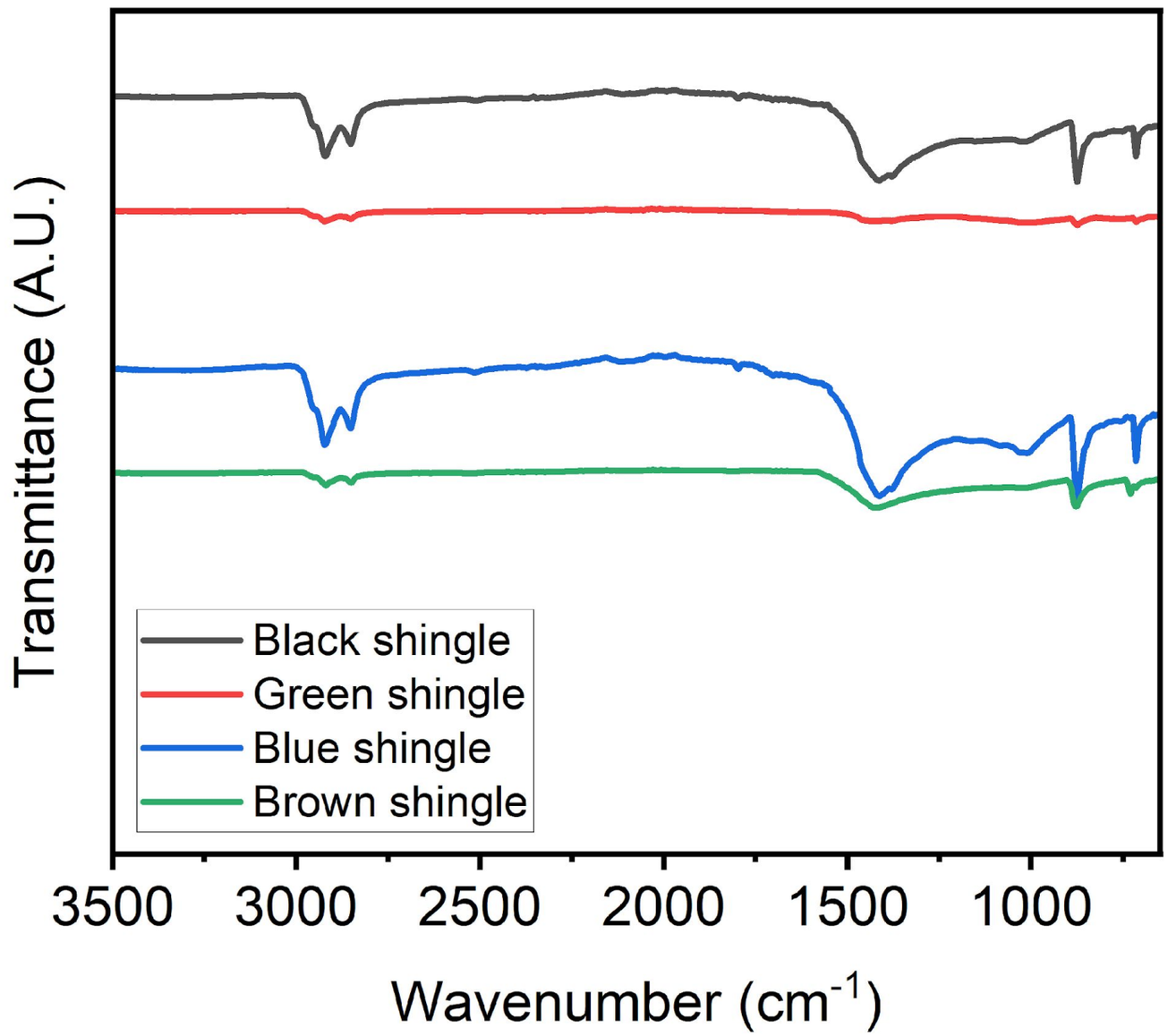
- Architectural shingle (~12 years old, blue)
- 3-tab shingle (~ 14-16 years old, brown)
- 3-tab shingles (new, black)
- 3-tab shingle (~ 4-5 years old, green)

- Formulations 1 and 2 were applied with a handheld garden pump sprayer (Vivosun, 0.2 gallon).

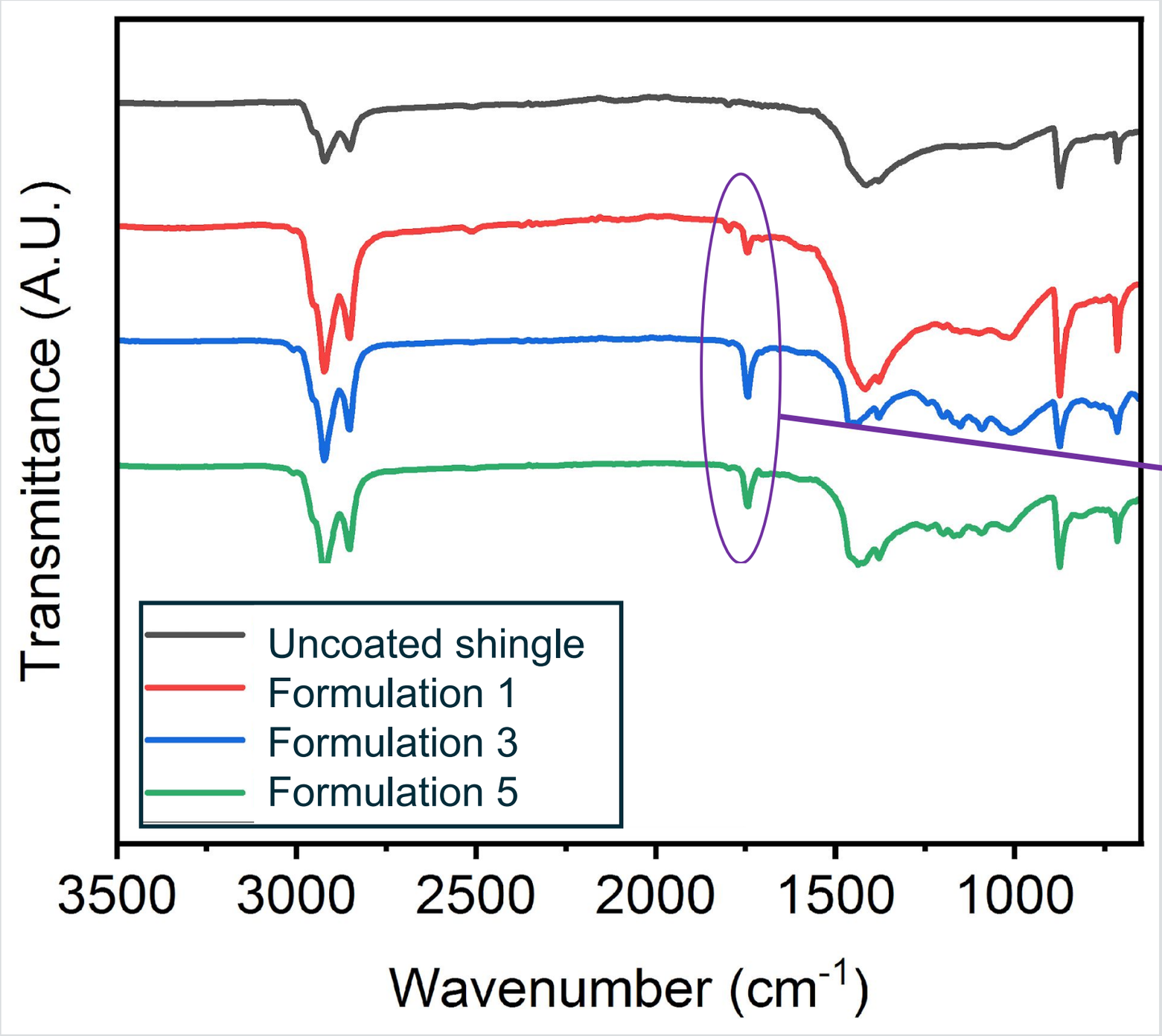


- The coated shingles were air dried at room temperature for 24 hours, before they were taken for FTIR measurements.
- About 15 g of formulation was applied to 1 ft^2 of each shingle.

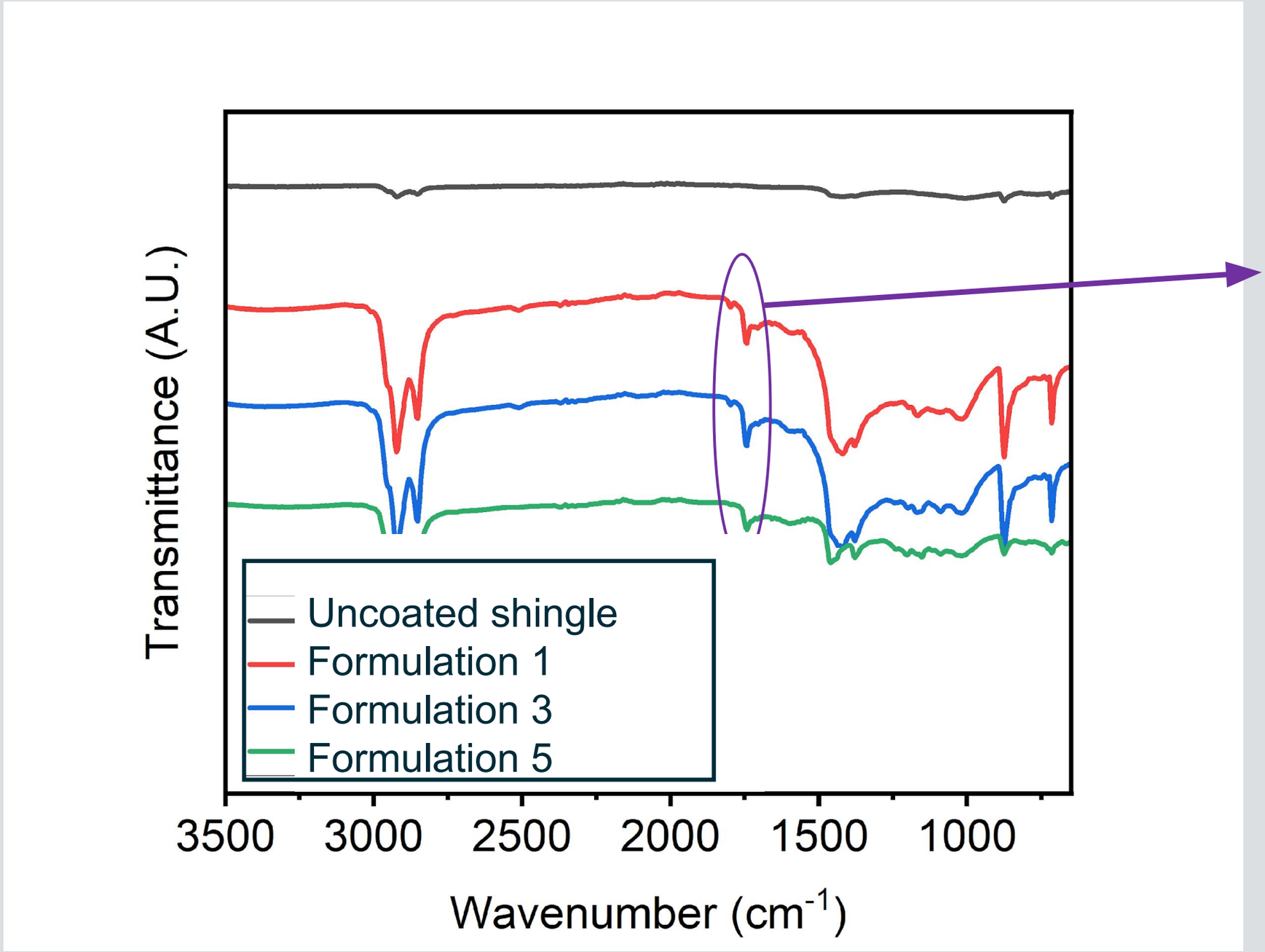
FTIR - UNCOATED SHINGLES



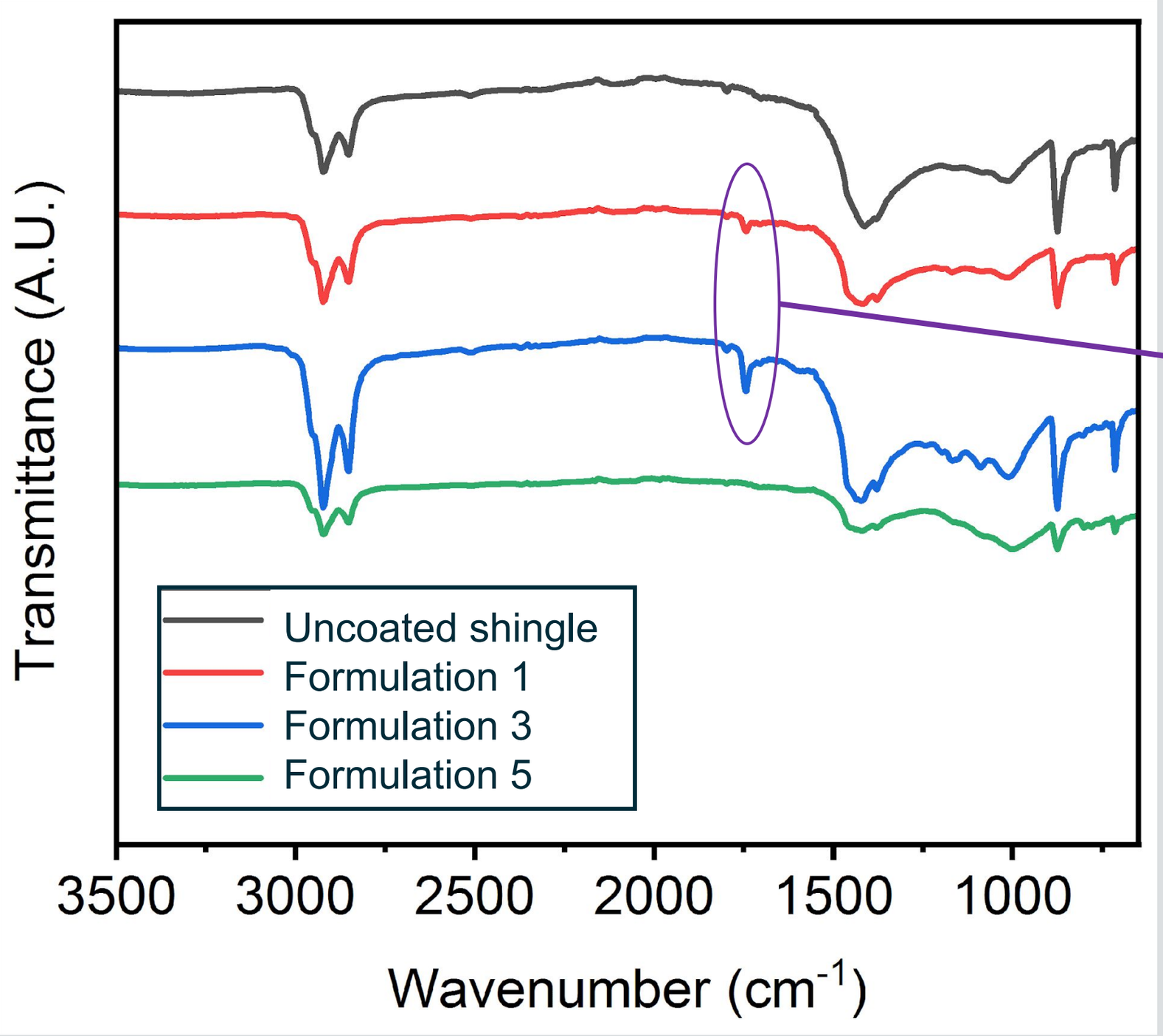
FTIR – BLACK SHINGLE (New)



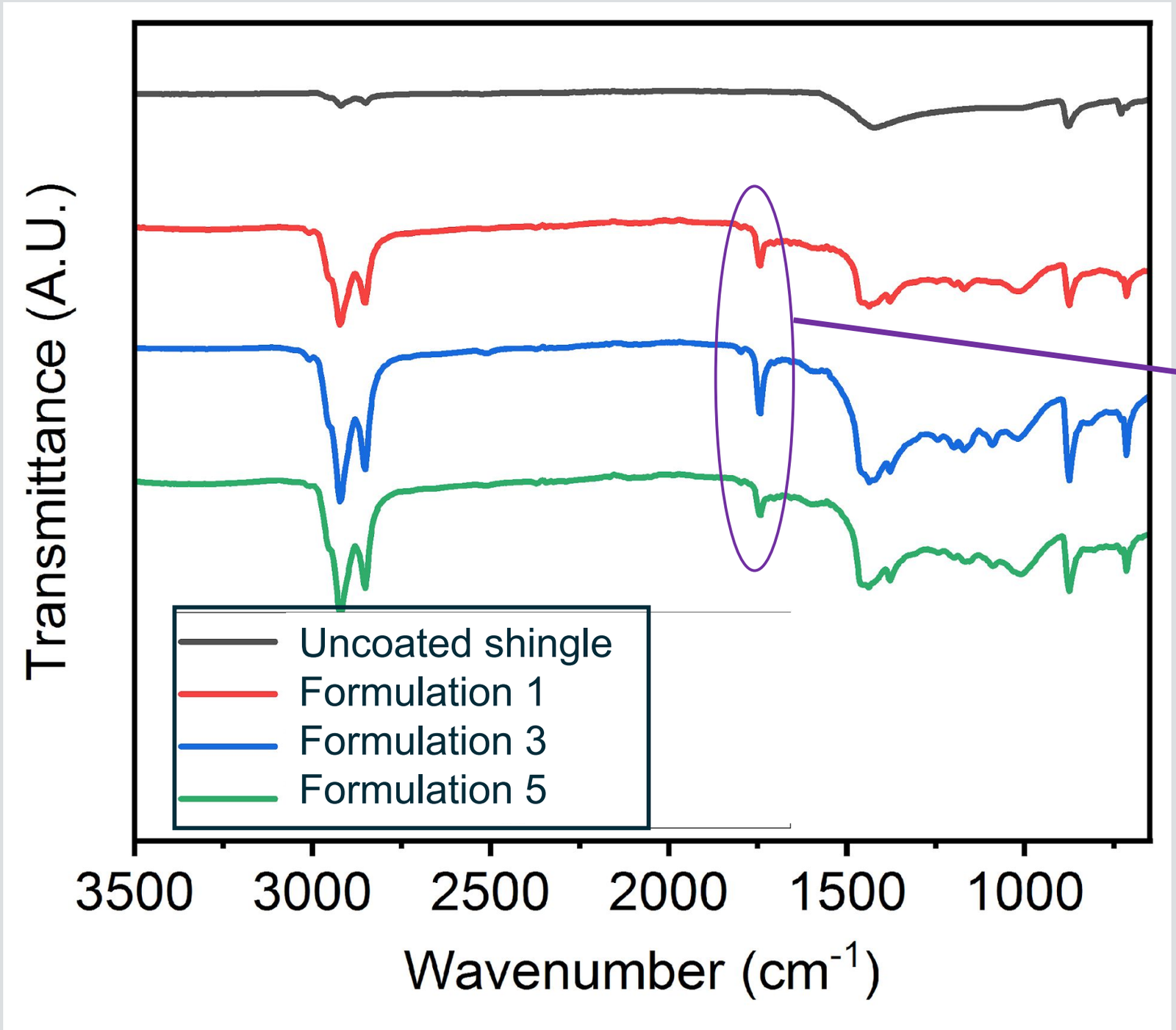
FTIR-GREEN SHINGLE (~4-5 YEARS OLD)



FTIR – BLUE SHINGLE (~12 years old)



FTIR – BROWN SHINGLE (~ 14-16 years old)



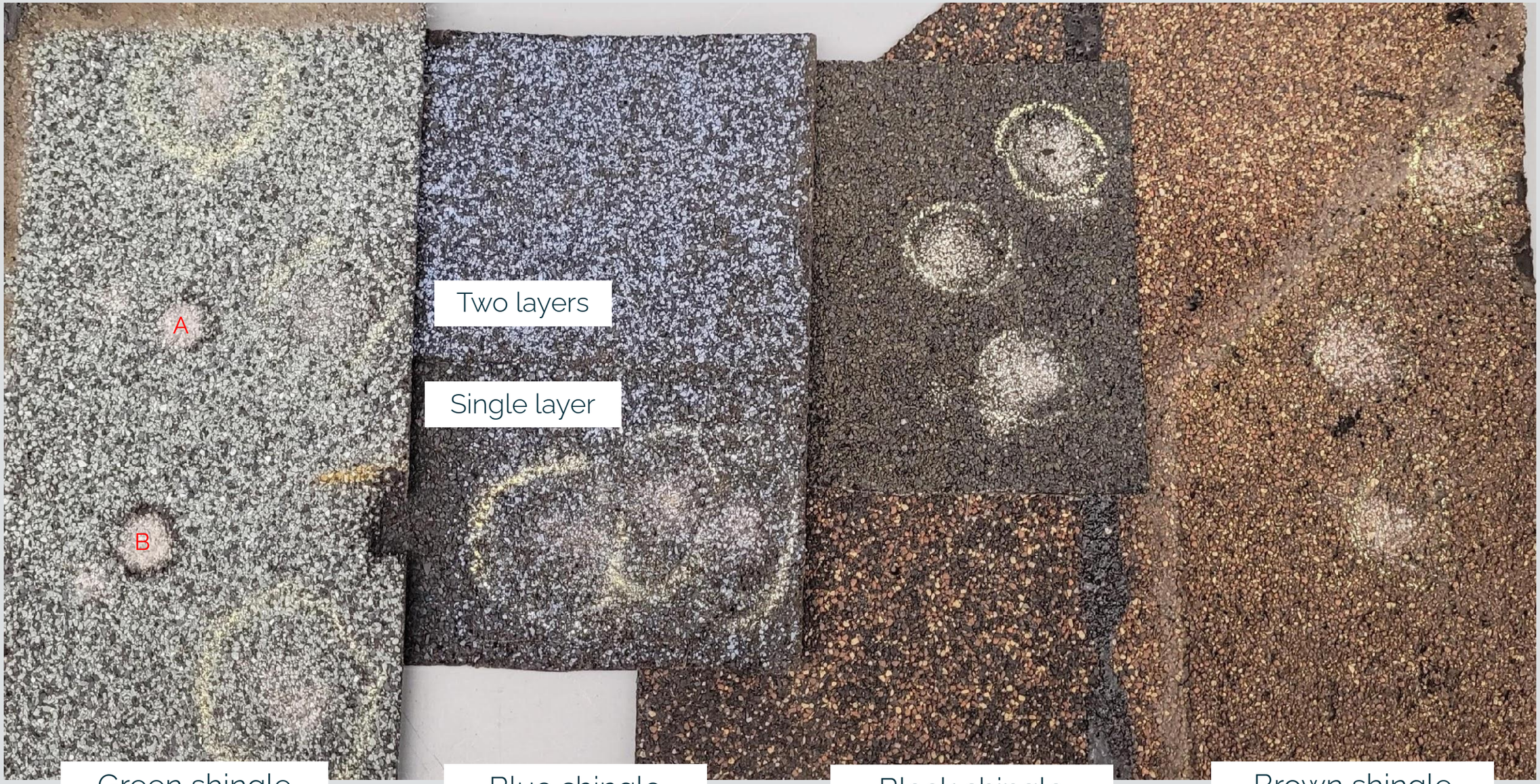
IMPACT TEST

- A picture of all shingles used for the experiment:

- Only the areas on top were used for the test (the areas that are exposed to air/rain/sunlight)

IMPACT TEST – UNCOATED SHINGLES

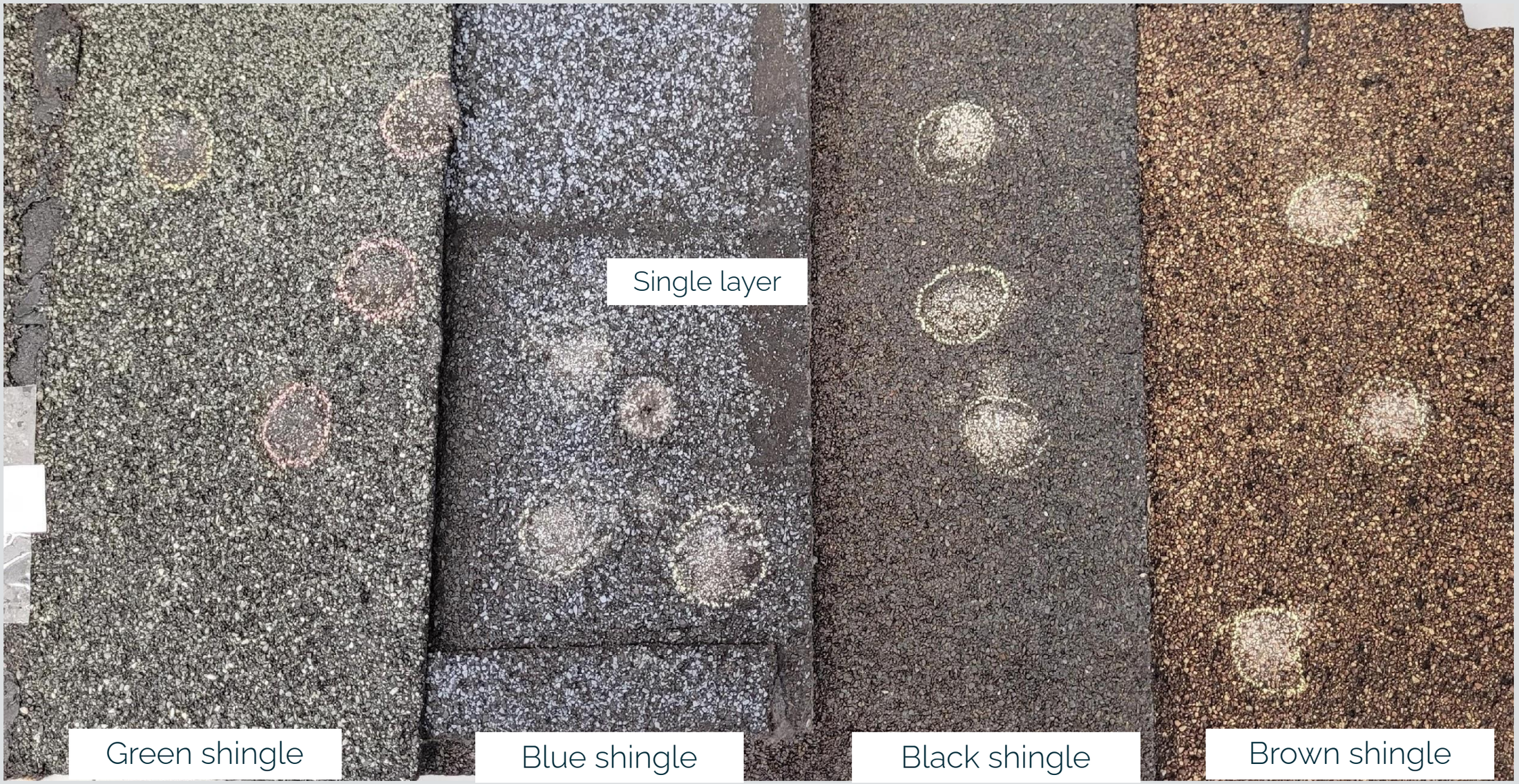
- Picture of all shingles (uncoated) after the impact of ball from 10 ft:



The deep indentations (A and B) were taken from 10 ft high, but without the piece of wood underneath the shingle.

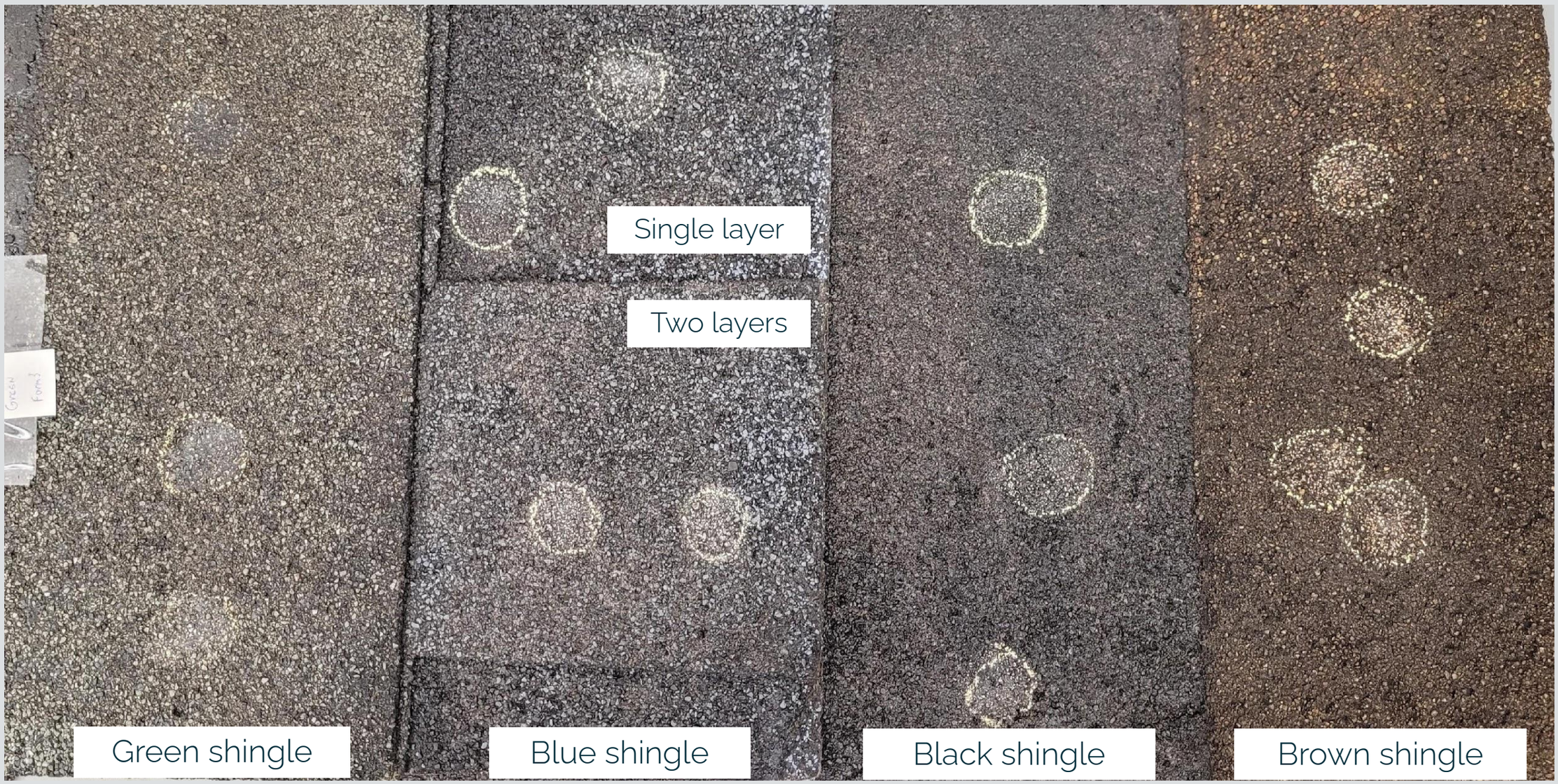
IMPACT TEST – SHINGLES COATED WITH COMPETITOR PRODUCT

- A picture of all shingles (with formulation 1) after the impact of ball from 10 ft:



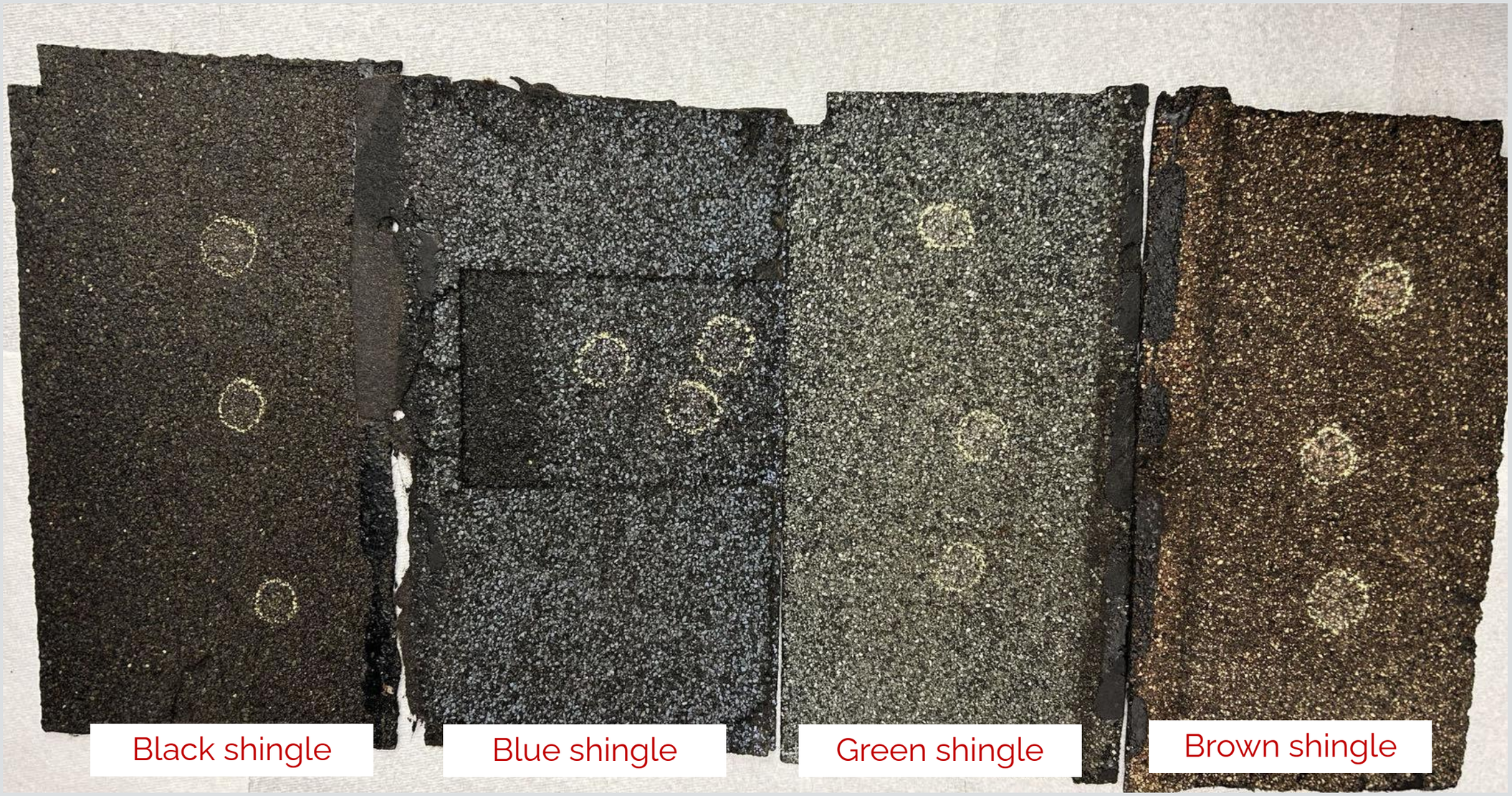
IMPACT TEST – SHINGLES COATED WITH GONANO REVIVE

- A picture of all shingles (with formulation 3) after the impact of ball from 10 ft:



IMPACT TEST – SHINGLES COATED WITH GONANO SHINGLE SAVER

- A picture of all shingles (with formulation 5) after the impact of ball from 10 ft:



IMPACT TEST-BLACK SHINGLE (3-TAB SHINGLE, NEW)

Black shingle	Average diameter (cm)	Depth*
Control	2.7	1, 1, 2
Competitor (formulation 1)	2.5	1, 1, 1
GoNano Revive (formulation 3)	2.3	0, 0, 1
GoNano Shingle Saver (formulation 5)	2.3	0, 0, 0

*Scale 0 to 3, where 0 represents no indentation on the shingle material, 1 represents a slight indentation, and 3 represents the deepest indentation.

IMPACT TEST-GREEN SHINGLE (3-TAB SHINGLE, ~4-5 YEARS OLD)

Green shingle	Average diameter (cm)	Depth*
Control	2.6	1, 1, 1
Competitor (formulation 1)	2.7	1, 1, 2
GoNano Revive (formulation 3)	2.4	0, 0, 1
GoNano Shingle Saver (formulation 5)	2.2	0, 0, 0

*Scale 0 to 3, where 0 represents no indentation on the shingle material, 1 represents a slight indentation, and 3 represents the deepest indentation.

IMPACT TEST-BLUE SHINGLE (ARCHITECTURAL SHINGLE, ~12 YEARS OLD)

Blue shingle	Average diameter (cm)	Depth*
Control	2.4	3, 3, 2
Competitor (formulation 1)	3.0	2, 2, 2
GoNano Revive (formulation 3)	2.5	1, 1, 1
GoNano Shingle Saver (formulation 5)	2.5	0, 1, 0

*Scale 0 to 3, where 0 represents no indentation on the shingle material, 1 represents a slight indentation, and 3 represents the deepest indentation.

IMPACT TEST-BROWN SHINGLE (3-TAB SHINGLE, ~14-16 YEARS OLD)

Brown shingle	Average diameter (cm)	Depth*
Control	2.9	3 (crack), 2, 3 (crack)
Competitor (formulation 1)	3.0	2, 2, 2
GoNano Revive (formulation 3)	2.9	1, 1, 1
GoNano Shingle Saver (formulation 5)	2.5	1, 1, 1

*Scale 0 to 3, where 0 represents no indentation on the shingle material, 1 represents a slight indentation, and 3 represents the deepest indentation.

CONCLUSIONS

- Formulation 3 demonstrated the best performance on impact test for all shingles samples (old and new).
- For older shingles (blue and brown), both Formulations 2 and 3 resulted in better impact resistance when considering indentation depth.
- For newer shingles (black and green), Formulation 3 resulted in better impact resistance when considering indentation depth.
- Indentation diameter might not be the best way to evaluate the coated shingle performance because sometimes the ball bounced a couple of times around the original indentation, resulting in some “broadening” of the diameter.

CONCLUSIONS

- Formulation 5 and 6 demonstrated the better performance on impact test for all shingles samples (old and new).
- Indentation diameter might not be the best way to evaluate the coated shingle performance because sometimes the ball bounced a couple of times around the original indentation, resulting in some “broadening” of the diameter.