Claims:

1. A process for producing a halogenated isoolefin copolymer, the process comprising contacting an unsaturated isoolefin copolymer cement, the cement comprising the unsaturated isoolefin copolymer dissolved in an organic solvent and having a water content of 1 wt% or greater based on a total weight of the cement, under halogenation conditions with a halogenating agent and an aqueous solution of a C_{1-20} organic peracid oxidant to form a two-phase reaction medium comprising an organic phase and an aqueous phase, the organic peracid oxidant capable of converting hydrogen halide to free halogen.

2. The process of claim 1, further comprising recovering halogenated isoolefin copolymer containing at least 0.05 mol% of chemically combined halogen.

3. The process of claim 1, wherein the unsaturated isoolefin copolymer cement is produced by polymerizing at least one isoolefin monomer and at least one copolymerizable unsaturated monomer in an organic diluent and removing the organic diluent and residual monomers by flash separation with steam.

4. The process of claim 3, wherein the at least one isoolefin monomer is isobutene and the at least one copolymerizable unsaturated monomer is isoprene, *p*-methyl styrene or β-pinene.

5. The process of claim 3, wherein the at least one isoolefin monomer is isobutene and the at least one copolymerizable unsaturated monomer is isoprene, and the unsaturated isoolefin copolymer further comprises one or more additional copolymerizable monomers selected from the group consisting of α-methyl styrene, *p*-methyl styrene, chlorostyrene, cyclopentadiene, methylcyclopentadiene and indene.

6. The process of claim 3, wherein the organic diluent comprises methyl chloride.

7. The process of claim 1, wherein the water content of the cement is 1.5 wt% or greater.

8. The process of claim 1, wherein the water content of the cement is 1 to 3 wt%.

9. The process of claim 1, wherein the organic peracid oxidant is a C_{1-4} organic peracid.

10. The process of claim 1, wherein the organic peracid oxidant is performic acid or peracetic acid.

11. The process of claim 1, wherein the organic peracid oxidant is pre-made and dissolved directly into the aqueous solution.

12. The process of claim 1, wherein the organic peracid oxidant is produced *in situ* in the aqueous solution by reacting an organic acid with a water-soluble oxidizing agent.

13. The process of claim 12, wherein the water-soluble oxidizing agent comprises hydrogen peroxide.

14. The process of claim 12, wherein the organic acid has a partition coefficient (*k*) between water and 1-octanol of from 0.05 to 24.55.

15. The process of claim 1, wherein the halogenating agent is Br_2.

16. The process of claim 1, wherein halogenating the unsaturated isoolefin copolymer is performed in an absence of emulsifier.

17. The process of claim 1, wherein the unsaturated isoolefin copolymer is present in the reaction medium in an amount of 10-33 wt%, based on total weight of the reaction medium.

18. The process of claim 1, wherein the unsaturated isoolefin copolymer cement is cooled before contacting with the halogenating agent and the aqueous solution of organic peracid oxidant.

19. The process of claim 18, wherein the contacting the unsaturated isoolefin copolymer cement with the halogenating agent is conducted for 1-60 minutes at a temperature in a range of 20-60°C.

20. A composition comprising the halogenated isoolefin copolymer prepared by the method of claim 1, the organic solvent, and the C_{1-20} organic peroxide oxidant, wherein the composition includes the organic phase and the aqueous phase.