Low VOC Low Odor SMC

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Agenda: Low VOC Low Odor SMC

- Objectives & Background
- Targets & Test Methods
- Technical Approach & Results
- Summary & Future Work
- Acknowledgements

Background

- Limited use of molded SMC parts in the interior of vehicles
  - Concerns over air quality and health
  - Styrene Regulations
  - Other volatile organic compounds (benzene, etc.)
- Sources of VOC and odor
  - Resin
  - Thermoplastic additives (LPA)
  - Styrene
  - Cure system (initiators and Inhibitors)
  - Other additives
  - Decomposition products during cure

Objectives

- Identify and minimize sources of VOC and objectionable odors in molded SMC samples.

- Develop and validate an *affordable* Ashland Arotran *resin-system* and SMC formulations with significantly reduced VOC and odor levels.

Project Targets – VOCs

- 0 VOC is not possible
- 0 styrene is an option
  - Cost increases as styrene decreases
- Focus on Low VOCs
  - Which test?
  - Test conditions?
    - Sample handling after molding – sealing/wrapping
    - Time between molding and testing
    - Sample temperature history
  - Total VOCs?
  - Specific compounds of interest?
  - Acceptable limits?

Project Targets - Odor

- No odor is not achievable. Significant improvements are possible.
- Simple to demonstrate improvements over existing standard formulas. Odor often becomes a moving target as the improved formulas are compared against each other.
- Very difficult to link VOCs with Odor.
- Odor tests are not well defined.
  - Seal the samples?
  - Heat the samples?
  - What is “objectionable” smell
  - How to quantify the intensity?

Test Methods – VOCs

- Industry standards
  - Numerous standards: Ultimately the OEMs need to meet emission standards as part of whole vehicle assessment.
    - Use material and component tests as predictors
- Ashland's test method
  - Modified VDA 278
    - Cryo-milled samples
      - Homogenous
    - Temperatures
      - 90° C VOC; 120 ° C fog
      - 60 ° C to simulate real world
  - Honda bag test method
    - Performed by 3rd party lab
      - Mimics conditions that could occur within an automobile
      - 60 ° C for 2 hrs

Test Methods – Odor

- Numerous methods
  - All with challenges - subjectivity
- Ashland method
  - Cut samples placed in sealed jars
  - Panel of 6 judges
  - Rank relative to a standard assigned a value of 10
- PSA Group D10 5517
  - Performed by 3rd party lab

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Technical Approach

- Focus on residual styrene after cure
  - Alternative monomers
  - Increase conversion (% cure)
- Design of experiments to study the effect of cure parameters
  - Curing system
    - type and level
  - Molding temperature
  - Molding time

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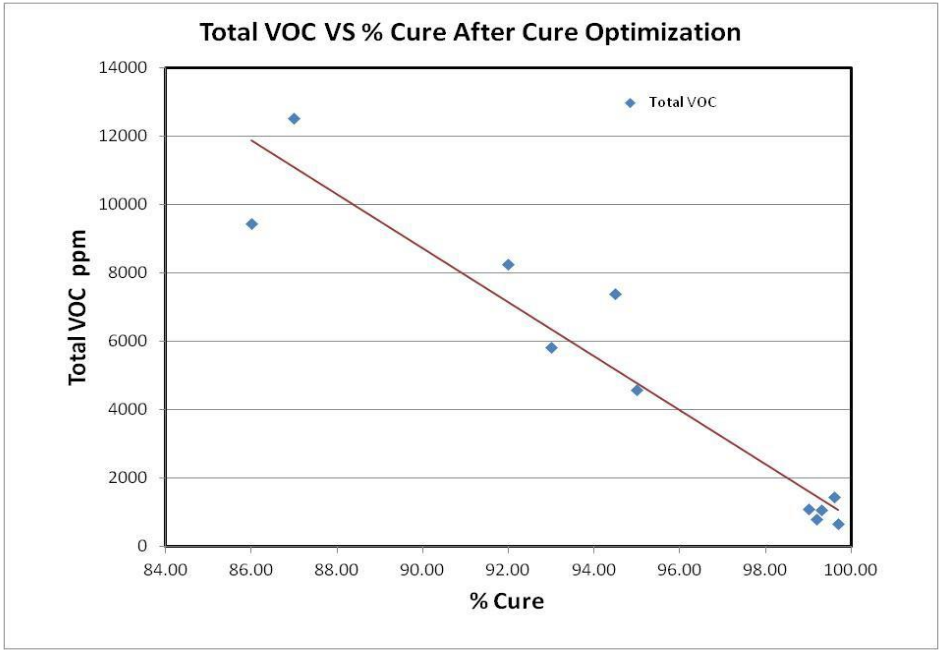
Technical Approach

- Optimization of cure system for no styrene and low styrene
  - Up to 99.7 % cure
  - Molding time 2 minutes
  - Molding temperature 140 to 160 C

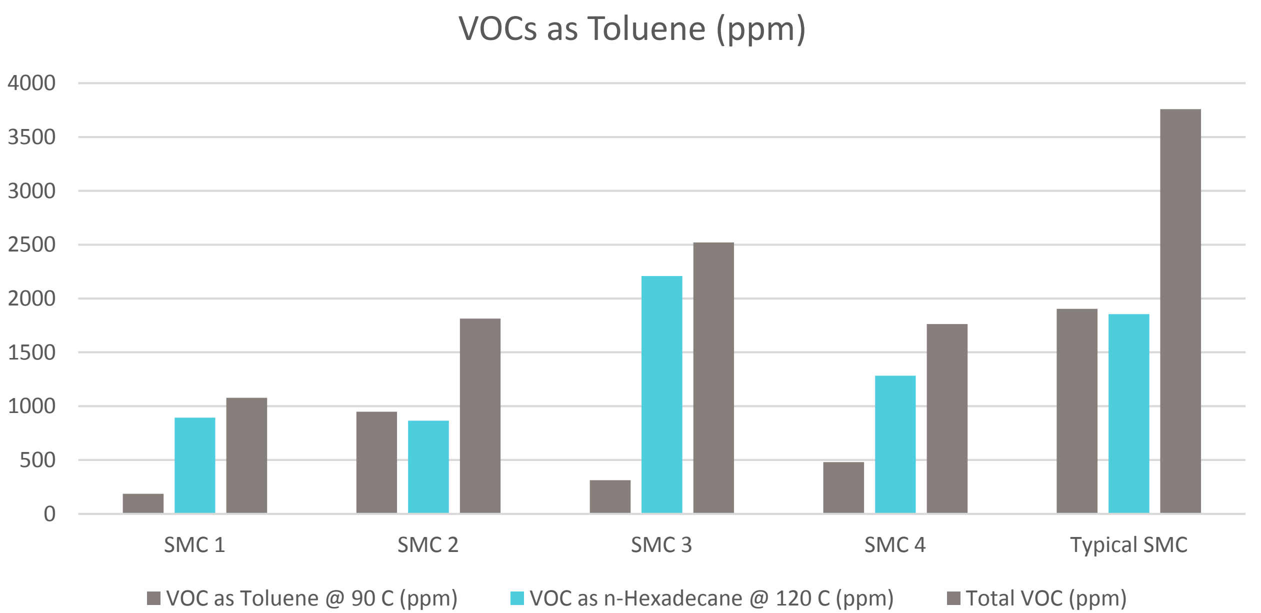


Technical Approach

- Understand effects of initiator type and level on VOCs
- Understand contribution of remaining additives:
  - LPA
  - Pigment
  - Viscosity reduction additives
  - Pigments
  - Etc.

VOC Test Results – Alternative Monomers

SMC	Styrene Level (%)	Alternative Monomer Level (%)	Residual Styrene as Toluene @ 90° C (ppm)
Typical SMC	50	0	1881
SMC 1	0	62	6.6
SMC 2	15.4	42.6	114
SMC 3	34	14	5.3
SMC 4	20	31.2	Not detected



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Comparison of VOC Analysis Methods

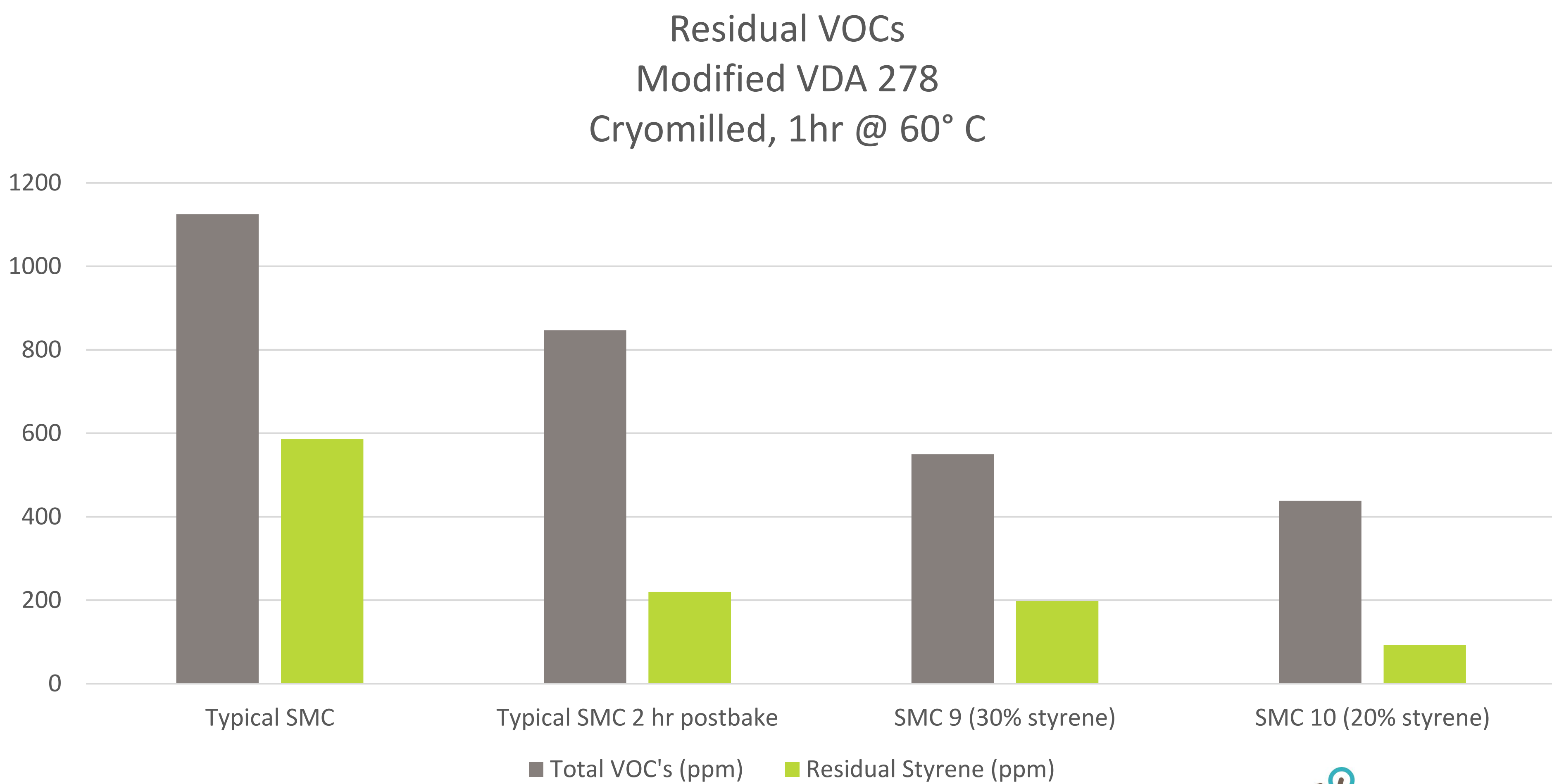
Ashland Modified VDA 278

SMC Formula	VOC as Toluene @ 90° C (ppm)
Control	3823
SMC 5	1480
SMC 6	1829
SMC 7	1472
SMC 8	1331

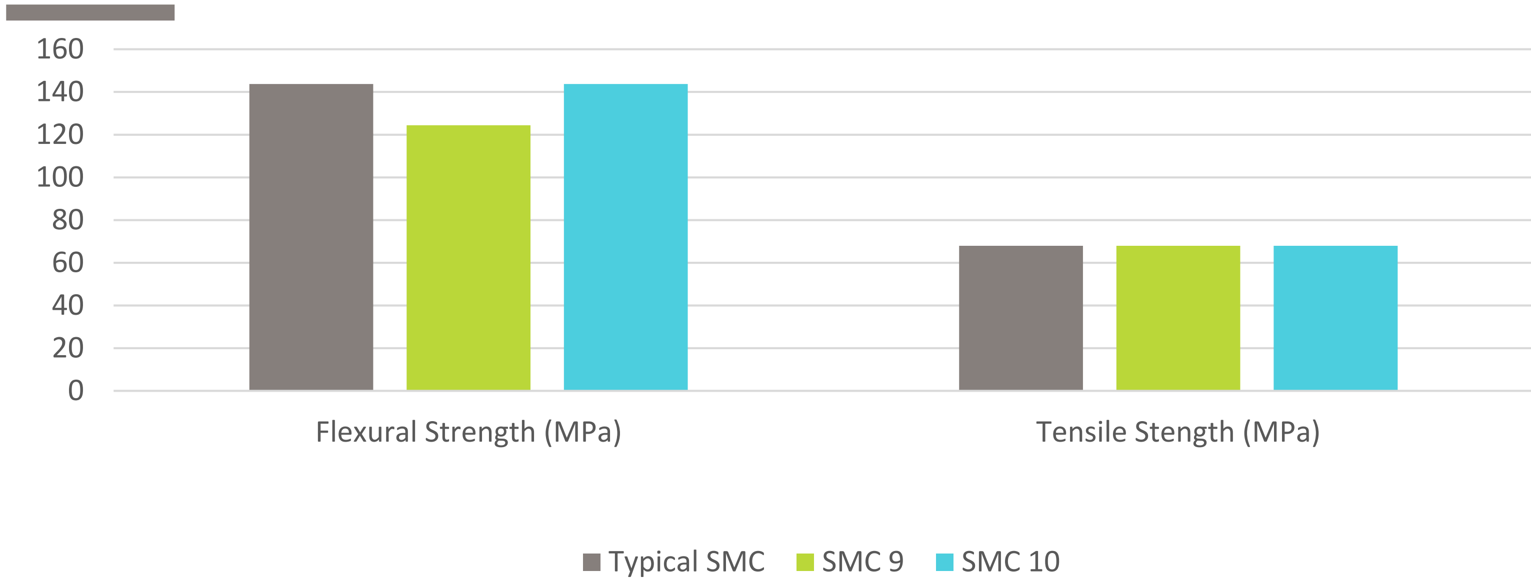
Honda Bag Method

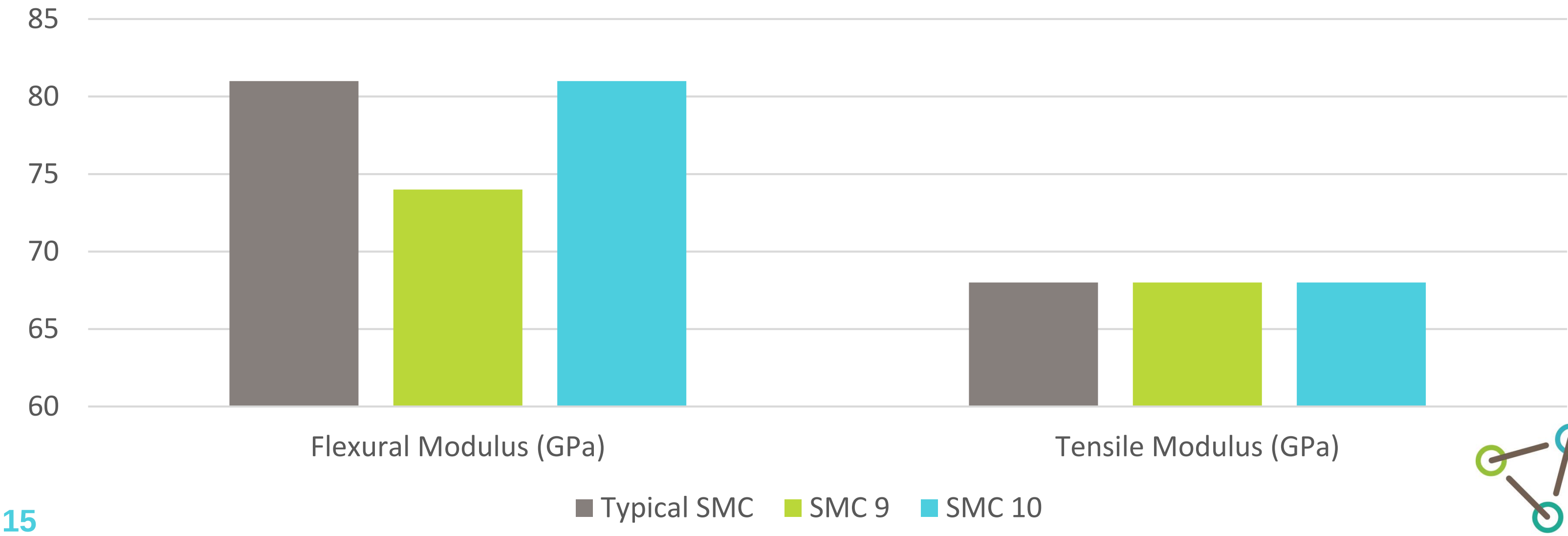
SMC Formula	T-VOC (µg/bag)
Control	5850
SMC 5	20.1
SMC 6	41
SMC 7	57.5
SMC 8	70.2

VOC Results


Residual VOCs
Modified VDA 278
Cryomilled, 1hr @ 60° C
1200
1000
800
600
400
200
0
Typical SMC
Typical SMC 2 hr postbake
SMC 9 (30% styrene)
SMC 10 (20% styrene)
Total VOC's (ppm)
Residual Styrene (ppm)

Mechanical Properties





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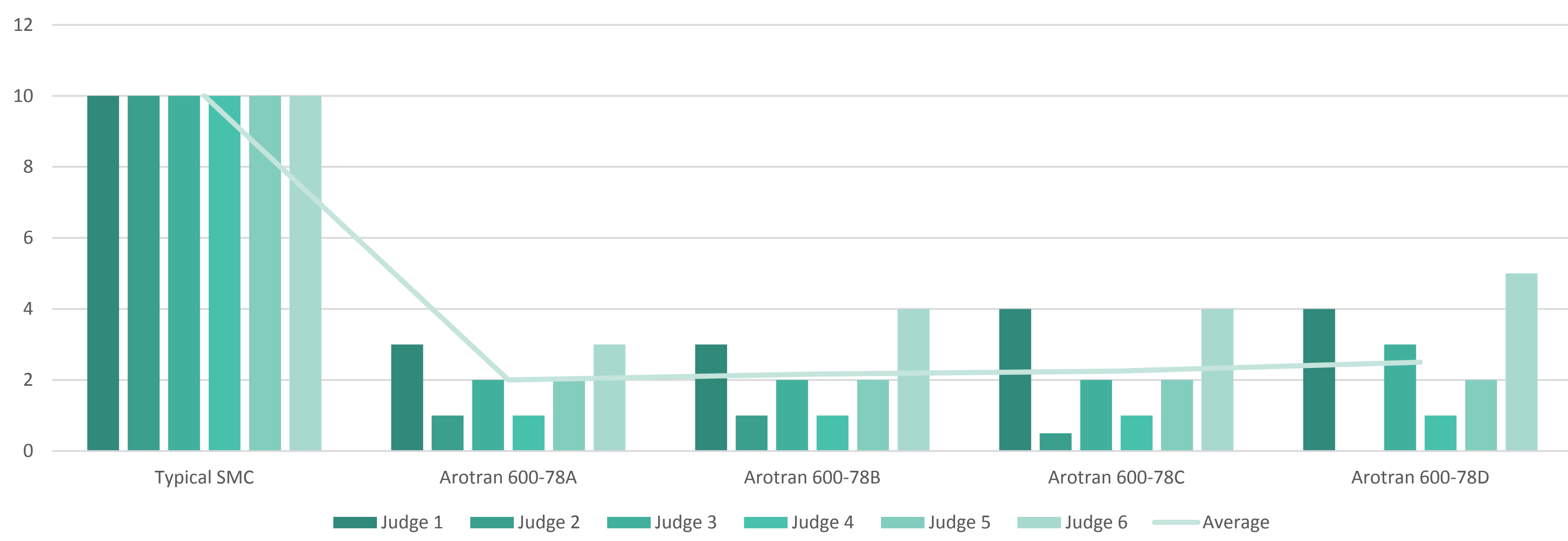
Odor Results – Ashland Evaluation



Odor Results – PSA D10 5517

- 9 SMC formulas tested by 3rd Party
  - 5 judges
  - Evaluated 6 total descriptors
    - Determine if present
    - Assign an intensity value
  - Only descriptor receiving a value was Piquant (Spicy)
  - Total scores ranged from 4.6-5.2

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Summary & Future Work

- Molding methods and materials (monomers, resins, SMC formulations) identified to reduce VOCs and odors in molded SMC samples.

- **Ashland Arotran 600 Resin System** developed to provide SMC compounders, molders, and OEMs with an **affordable low VOC low odor solution**.

- Continuing work:
  - Continue with experiments to study effect of alternative initiators on VOCs
  - Link odors to VOCs
  - Maximize amount of styrene while maintaining low VOC and low odor
  - Study the effect of inhibitors on conversion

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