Understanding how products are reverse engineered

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Outline for presentation

- Background for presentation
- Objectives for the presentation
- “Dry-lab” versus “wet lab”
- Strategies for conducting reverse engineering projects
- Considerations for the use of knowledge gained by reverse engineering efforts
- Conclusions

Background for presentation

- The chemical enterprise is changing
  - An ever-increasing percentage of chemical sales are coming from small chemical business and they need competitive edge
    - Everyone wants to cut costs
    - Everyone wants to get into market as fast as possible
  - Small chemical businesses often provide innovative technology or sell to clients not wanted by larger companies
  - Business is more international than ever and products need to be sent to locations outside jurisdiction of US courts
  - Regulatory requirements often require full disclosures that small companies cannot or will not provide
- Therefore, there can be a perceived need to reverse engineer competitive or purchased products

Objectives for presentation

- Discuss why companies fail to consider that their products can be reverse engineered
- Discuss why companies will consider reverse engineering purchased or competitive products
- Discuss strategies for conducting reverse engineering exercises
  - "Dry lab" exercise (see what information is available)
  - Partial reverse engineering
  - Complete reverse engineering
- Show how to evaluate success of reverse engineering efforts

Why some companies fail to guard against reverse engineering

- Our recipe (ingredients and/or processing) is secret
- Part or all of our formulation and/or processing conditions are protected by patents
- We make a specialty additive that is used at trace levels in our customers' complex formulations; we can't find it after they use it in their products
- We make our clients sign an agreement not to reverse engineer our products or transfer them to others
- Our lawyer gives out only information our customers' lawyers need for regulatory filings

Why some companies use reverse engineering

- They want to get into a new market quickly and without taking a license from your company
- Your product is dominating the market, and your competitors want to find out why
- You suspect a competitor is infringing on your patents
- Your company is sole supplier and/or your prices are perceived as being too high
- Your customer needs a detailed formulation to meet its regulatory requirements, and you cannot or will not provide it

Becoming a successful reverse engineer

- Advice from old boss: He said my analytical group must
  - Tell him if our company's products were being correctly made in our pilot plants and our factories
  - Tell him how our competitors made their products (especially the ones that were growing market share)
  - Tell him how we could make our products better
- Reverse engineering is generally project-oriented work
  - You need to know when you are done (specific information to be provided)
  - You should develop a project plan to describe to management when you will have results for them and the resources you will use

Google should be the first reverse engineering tool you use

- Why Google comes before information specialist
  - Even if you have access to a information specialist, you still need to know the questions you want answered
  - It helps identify possible search terms
  - It may provide leads on consultants and laboratories specializing in reverse engineering
  - You may even learn something about the technologies your company is using
  - Google may show some patents, but it is not a substitute for a patent search
  - It also can pick up leads on environmental permits and discharge limits (what is coming out may tell what is used)

Working with an information specialist

- Once your information specialist starts working on your project, you will not lack for reading material
  - Patents and patent applications
  - Scientific and trade literature, meeting abstracts
  - Reports from your company and associated companies
  - MSDS sheets and other technical information
  - Government reports
- Follow-up discussion with the information specialist
  - Provide feedback on information provided
  - Decide if you have enough (you may have found the answer) or go for more in-depth searches

Talk with internal experts and company consultants

- A good reverse engineer knows the technology he/she is investigating
- You may get useful or not-so-useful information on what product development and process development thinks about your efforts
- You will likely need their help in several areas
  - Helping make sure you have read necessary company reports, patents, trade journal articles
  - Understanding competitive products
  - Making model formulations for you if you need to have lab work done – many industrial products are mixtures of mixtures

Learning from outsiders

- Chemists are lonely and want someone to talk to, you need to be a good listener for them
  - The product you need to investigate may be made a thousand miles away, but have a local connection
  - Attend your local and regional ACS meetings and appropriate trade group meetings
- Be out in front when sales and marketing tour R&D
  - Oftentimes sales and marketing personnel will be meeting with your company's customers and will know how competitive materials are performing
  - Before Health & Safety required sample labeling, mysterious samples would arrive on your desk

Heading for the laboratory?

- Reverse engineering efforts generally require multidisciplinary approach with the best scientists and equipment you can obtain; do you have the resources?
- Successful reverse engineering efforts can be costly, so you need to make sure you have arranged for more than adequate financial resources and personnel
- If you are blessed with the latest instrumentation, use it; but be aware that simple microscopes, IR-microscopes, size-separation LC, and bench-top GC/MS systems in expert hands can be effective reverse engineering tools

Reverse engineering strategies - 1

- "Dry lab"
  - Literature searches yield sufficient information to prepare and evaluate samples formulated from literature information
  - May not have exact reproduction of formulation, but it is close enough for commercial purposes
- Partial reverse engineering
  - Sufficient laboratory work done to provide answer related to one part of the formulation
    - Density separations to find amount of a less dense additive
    - Identification and estimation of concentration of a plasticizer for a polymeric system
  - Sometimes simple reverse engineering efforts done on routine basis to monitor changes in competitive products

Reverse engineering strategies - 2

- Full reverse engineering
  - Sufficient laboratory work done to provide complete answer as to ingredients and processing of competitive products
    - Complete separation of main ingredients and additives
    - Identification and estimation of concentration of additives, even at trace levels
  - Success of effort often judged by performance of test product made with information from reverse engineering efforts
    - Can all ingredients or reasonable substitutes be obtained?
    - Can processing conditions be duplicated?
  - Project may extend over several years; particularly, if staff and equipment need to be added to complete the project
  - A project steering committee can be useful

Some reverse engineering successes and failures - 1

- Determine ratio of high-mw polymer to low-mw polymer in elastomeric adhesive
  - Room temperature GPC with fraction-collection and IR
  - Project failed due to insufficient chromatographic resolution and inexperienced investigator
- Determine composition of rapid-curing adhesives based on specialty acrylate esters and additives
  - Room temperature small molecule GPC with fraction-collection and NMR and IR of fractions
  - Project was technical and financial success, as it allowed rapid entry into marketplace with competitive product line

Some reverse engineering successes and failures - 2

- Determine proportions of ingredients in new and improved competitive bakery formulation
  - Changes in ingredients statements provided clues
  - Density gradient separation allowed estimation of relative amounts of similar ingredients
  - GC and LC analyses provided levels of other ingredients
  - Project was partial success, in that additional equipment had to be obtained to understand processing of lipid components

Some reverse engineering successes and failures – 3

- Full reverse engineering of major cigarette brand
  - Project took over five years from start to completion
  - Outside experts and high-end testing laboratories hired and worked on project initially
  - Major findings were achieved with benchtop GC/MS systems, but instruments run and data interpreted by in-house experts
  - Formulation of target competitive product was changed during life of the project
  - Some of the analytical findings were doubted because they did not fit usual explanation of hedonic properties
  - Significant additional work has to be done to overcome critics
  - Project was technical success, but it would have been more of a success if project findings had been used in full

Conclusions - 1

- Companies should not conclude that their proprietary formulations cannot be reverse engineered just because they are complex or use special processing
- Complex reverse engineering efforts require good knowledge of the technologies likely used to make the product that is to be reverse engineered
- Simple analytical instrumentation run by product-knowledgeable scientists can often outperform complex instrumentation run by analytical specialists
- Good project planning is essential

Conclusions - 2

- Physical separations of complex mixtures, which can be time-consuming, often provide information that would have been missed if entire product analyzed
- Criteria for success of reverse engineering efforts should be established at project planning time
  - Provide definition of project completion
  - Identify situations where differences in ingredients and/or processing conditions will prevent full duplication of competitive product